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PLC-Based Electric Hybrid Control of Assembly Line Manipulators from Robust Testing to Chaos Modeling

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Abstract:Taking Mitsubishi FX3U-48MR programmable controller as the control center, it drives the electric of the assembly line manipulator, and the servo driver drives the servo motor. The PLC-based assembly line manipulator electric drives the motion of the manipulator through the synchronous belt drive, which can realize the accurate position control of the manipulator. The proposed model will A Gaussian mixture distribution with heavy-tailed distribution characteristics is used as the model output likelihood function, and a parameterization method for the design of a full-dimensional PI observer with robust fault detection is established.

Keywords:PLC, Electric Hybrid Control, Line Manipulators, Robust Testing

1. INTRODUCTION

With the rapid development of the domestic manufacturing industry, the development and application of automatic line technology has been greatly promoted [1], which not only achieves the improvement of product quality and production efficiency, but also has significant effects in reducing energy consumption, improving the working environment and reducing material costs [2]. As equipment becomes more efficient, and accordingly higher quality of operators is required, automatic line technology is considered a robust system. This design is aimed at an automatic line consisting of 5 units of feeding, processing [3], assembling, sorting and conveying. The conveying unit is the most important in the automatic line, and it is also the working unit with the most heavy tasks [4].

The main task of this unit is to precisely position the drive grabbing manipulator to the material table of the designated unit [5], grab the workpiece on the material table, and then transport the grabbed workpiece to the designated place and put it down [6]. The gripping manipulator is a work unit that can realize 4 degrees of freedom movement. Chaos is a seemingly irregular, random-like motion that occurs in deterministic systems in nature. More and more time series with chaotic characteristics are obtained from actual systems, such as atmospheric circulation, temperature, rainfall, sunspots, the Yellow River [7]. In recent years, the prediction and analysis of chaotic time series has become a research hotspot in the field of scientific research [8]. Due to the strong nonlinear approximation ability of neural networks and support vector machines, it has been widely used in chaotic time series modeling and forecasting [9].

The failure of equipment and systems will not only affect the safe operation of the system, but even cause casualties and environmental pollution [10]. With the continuous improvement of product quality, production efficiency and safety in modern production, dynamic system fault detection technology has attracted more and more people's attention, and has developed [1] rapidly in recent years. With the rapid development of new technologies such as computer science and computational intelligence, many new methods and technologies have been introduced into the field. Digital watermarking technology is divided into fragile digital watermarking technology [12] and robust digital watermarking technology according to the application field. Fragile digital watermarking technology can detect any tampering of images or resist conventional compression such as JPEG [13], but it is not suitable for It has strong sensitivity when the image content changes a lot, and is mostly used for image integrity authentication. Robust digital watermarking can resist such as filtering [14]. Pneumatic automation control technology is the use of compressed air as the working medium for transmitting power or signals, with the main components of the pneumatic control system, and the mechanical, hydraulic [15], electronic and other parts or all of the integrated control loop, so that the pneumatic components work in accordance with the requirements of the production process. Condition, an automation technology that automatically acts in accordance with the set sequence or conditions [16].

Since the advent of manipulators in the early 1960s, after more than 40 years of continuous development, the position of manipulators in machinery manufacturing has become more and more important [17]. The development of manipulators has roughly gone through three generations. The first generation of machinery is a program-controlled manipulator, which uses a point control system to control its actions and cannot respond to the external environment [18]. Most of the manipulators used now belong to this category. The second-generation manipulator has sensory organs and is still based on program control, but the control program can be corrected according to external environmental information [19]. The automated production line experimental platform is mainly composed of the following five working units, namely: assembly unit, feeding unit [20], conveying unit, processing unit, and sorting unit. Each work unit can not only act as an independent system that operates autonomously. The device is integrally installed on the sliding plate of the servo drive assembly [21], and is driven by the synchronous belt to make a linear reciprocating motion, positioned to the material table of other work units, and then completes the function of grabbing and putting down the workpiece. Accurate positioning of the manipulator is critical for picking and placing workpieces. The design takes Mitsubishi FX3U-48MR programmable controller as the control center [22].

2. THE PROPOSED METHODOLOGY

2.1 The Robust Testing and Chaos Modeling

The extreme learning machine makes the data have linear characteristics in the high-dimensional space by mapping the

input variables [23] to the high-dimensional space, and then processes the data in the high-dimensional space. At present, the most commonly used training method for extreme learning machines is the pseudo-inverse method [24]. Although the pseudo-inverse method is simple and easy to implement, it is prone to ill-conditioned solutions in practical applications, that is, the output weight is very large. Given a nonlinear feedback chaotic system (1), design a full-dimensional solution of the form (3) PI observer, solve the observer gain matrix, K and weighting matrix G so that the following conditions are established: 1) The matrix A is non-degenerate and its eigenvaluesall have negative real parts; 2) The robust fault detection condition (10) is established.

As an indicator of the signal, the residual signal must respond to the fault signal. The image is mapped to a new position, and the positions of this image are in one-to-one correspondence, not repeating each other, and the distance between the image blocks is far away, so that in the In the process of image tampering, another image block will not be affected because one image block is tampered with. Arnold transform is mainly used to select TB and EB in this algorithm. Given an initial position of Arnold and the number of times of scrambling, the image block is composed The correlation between TB and EB makes TB and EB spread all over the whole image in the algorithm, which improves the traversability of training and embedding watermark blocks. The instructions of the processor are rich and powerful, in addition to all the traditional bit manipulation instructions, timer counter instructions , data transfer instructions, arithmetic operation instructions, comparison instructions, sequence control instructions, and program control instructions, there are also powerful input and output instructions, array file operation instructions, trigonometric function instructions, advanced arithmetic instructions, exponent, logarithm, and arithmetic conversion instructions .

The output likelihood function of the model with heavy-tailed distribution makes the model more robust to outliers. Gaussian mixture distribution, as an approximate Student-t distribution, is still robust to outliers. The univariate distribution is For example, the probability density curves of Gaussian distribution and Gaussian mixture distribution are shown in Figure 1 and Figure 2 in both cases without and with outliers. The histogram distribution of 300 integer points from the Gaussian distribution, and its The maximum likelihood estimation curve of Gaussian distribution and Gaussian mixture distribution is shown in Figure 1. The original host image X is divided into non-overlapping n×n small blocks, and the characteristics of the image blocks are extracted at the same time.

2.2 The PLC-Based Assembly Line Manipulator

The automatic production line experimental platform is mainly composed of the above-mentioned five units, and the main content is to realize the content of the following four processes, that is, assembly, feeding, sorting, and processing. The above four processes are connected in series by the conveying unit to realize the whole process of the automatic production line. The details can be seen in Figure 2 below: The system composition takes Mitsubishi FX3U-48MR programmable controller as the control core, and consists of a touch screen, a robot position detection module, a robot position control module, and a network communication module.Mitsubishi FX3U-48MR programmable controller is the core part of the robot position control system. The PLC (master station) of the conveying unit reads the working status of the other 4 units from the PLC (slave station) of the other 4 units through the network communication module. The characteristics of the pipeline The pipeline process is composed of several related sub-processes, and each sub-process is called the "stage" or "segment" of the pipeline.

The number of pipeline segments is also called the “depth” or “pipeline depth” of the pipeline. The time required for each sub-process to be implemented by a dedicated functional segment should be as equal as possible, otherwise, the long functional segment will become the bottleneck of the pipeline, which will cause "Blocking" and "breaking flow" of the pipeline. This time is generally one clock cycle beat or one machine cycle. Its working mode is periodic cyclic scanning. The scanning cycle is an important indicator of the control process, and the length of the required time determines the speed of the control. The entire working process can be divided into three stages: input processing, program execution and output processing. The completion of these three stages is called a scan cycle of the programmable controller, and during the entire running process of the system, the programmable controller takes a certain amount of time. The scanning speed keeps repeating these three processes.

The control unit selected by the assembly unit is Mitsubishi FX3U-48MR relay output type PLC. The control unit needs to control 13 output points and 20 input points; among them, the 20 input points are: 16 detection sensors, 4 buttons and switches; the 13 output points are: the 3 outputs displayed by the control indicator lights point. The robot position control module is mainly composed of Panasonic AC servo driver.

2.3 The PLC Manipulator Electric Hybrid Control

The control unit selected for the sorting unit is the Mitsubishi FX3U-48MR relay output type PLC, and the configuration of the Mitsubishi FX3U-3A expansion module is used to realize the auxiliary control. The control unit needs to control 8 output points and 13 input points; among them, 13 input points are: 6 detection sensors connected to the 3-phase rotary encoder. The function of network communication: during the working process of the position control system, the transmission As the master station of network communication, the unit's PLC continuously reads the working status of the other four units from the storage units of the other four slave stations, providing the basis for the PLC of the conveying unit to call different position control programs.

The corresponding histogram distribution and the maximum likelihood estimation curve based on different distributions generated by adding 26 outliers to the above dataset are shown in Figure 2. It can be seen from Figure 2 that the Gaussian distribution is very sensitive to outliers, while the Gaussian mixture The distribution has strong robustness and is not easily affected by outliers. To verify the effectiveness of the algorithm, an 8-bit grayscale image of 512 × 512 is used as the test image, and a 32 × 32 binary image is selected as the watermark image (As shown in Figure (3)), take K1=15, K2=0.4. At the same time, the peak signal-to-noise ratio (PSNR) is used to measure the important feature of watermark invisibility. At the same time, in order to verify the quality of the extracted watermark, it can be obtained from the above figure, in the control system without any control algorithm, the output response of the system oscillates, which cannot occur in engineering applications. When the controlled object's pneumatic manipulator is subject to some external disturbance and the controlled parameter deviates from the expected value, because there is no control algorithm, its

automatic compensation effect is limited, and the control accuracy of the system is difficult to guarantee.

The following will introduce and step-by-step control algorithm to control and simulate it. The control unit selected by the assembly unit is the Mitsubishi FX3U-48MR transistor output type PLC. The control unit needs to control: 11 output points and 14 input points; among them, the 14 input points are: 10 detection sensors.

3. CONCLUSIONS

Using PLC, servo driver, servo motor, touch screen and network communication, the position control of the manipulator can be completed more accurately. The Robust-ELM prediction model is proposed under the Bayesian framework. The proposed model not only has the model based on the Bayesian learning method The automatic parameter learning ability avoids the process of selecting regularization parameters for cross-validation. At the same time, the proposed model uses the mixed Gaussian model as the output likelihood function of the extreme learning machine, which improves the robustness of the model.

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