Research on CNC Machine Tool Motion Control System Based on Image Processing

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Abstract: The accuracy of motion control of CNC machine tools directly affects the quality of industrial development. Traditional CNC machine tools have a series of problems such as low control accuracy and slow adjustment speed. Image processing technology is used to improve the motion effect of CNC machine tools. Through image acquisition, image analysis and motion control, the starting point of machining is defined, and the operation is carried out according to the requirements to improve the efficiency of tool operation. Image analysis algorithm is used to control the starting point coordinates of the tool, and the tool is moved to the top to achieve horizontal alignment. This method can not only ensure that the system has a faster control speed, but also ensure that the accuracy of the control is significantly improved.

Keywords: Image Processing; CNC Machine Tools; Kinetic Control System

1. Introduction

With the rapid development of machining technology and science and technology, the current mechanical products in the use process want to improve the precision of product production, and meet the complex and diversified needs, need to adapt to product characteristics, change machine tools and process equipment, through the open digital control system to solve the problem of low precision in the past, not only improve the development speed of manufacturing industry, but also save production space and cost. Use the control program to process the whole product, determine the operation procedure of the tool, and improve the machining accuracy of the workpiece.

2. Overview of CNC Machine Tool Motion Control System

One of the core technologies of modern manufacturing industry is the motion control system of CNC machine tools, which reflects the development process of automation and intelligence in manufacturing industry. In the initial stage of industrial development, CNC machine tools mainly use open-loop control system. Due to the rapid development of science and technology, the current closed-loop control system has gradually become one of the mainstream of social development. At present, the motion control system of CNC machine tools is developing towards the direction of high precision, high speed and intelligence, and many new technologies and methods have emerged. The traditional motion control system of NC machine tool includes: NC device, servo drive system and mechanical actuator. The purpose of NC device is to receive, process and process various programs, and generate various control instructions; Through the servo drive system, the control command can be gradually converted into mechanical motion; Various processing operations can be completed by using mechanical actuators. Although the use of this system has realized automatic processing to a certain extent, it still has some limitations. For example, there is a problem in the system itself, that is, it is difficult to adjust processing parameters in real time due to its poor adaptability to changes in the external environment; The machining accuracy of complex shape workpiece is limited; Lack of real-time monitoring and quality assessment capabilities for the processing process. The application of image processing technology in CNC machine tools provides a new way to solve the above problems. Using image acquisition equipment and processing algorithm, the visual information that can be obtained by CNC machine tools in the processing process can realize the real-time monitoring of workpiece shape, size and surface quality. This kind of visual feedback can be used to correct machining errors, optimize machining paths,

detect machining defects, etc., so as to significantly improve machining accuracy and efficiency. In addition, image processing technology can also be used for tool wear detection, workpiece automatic recognition and positioning, and further improve the intelligent level of CNC machine tools[1].

3. Research on Motion Control System of CNC Machine Tool Based on Image Processing

The motion control system of CNC machine tool based on image processing, in the process of design, the overall system includes the following different modules, respectively: image acquisition and processing module, motion control module design and other parts. In the process of the overall architecture of the system, the hierarchical design idea is used to divide the system into perception layer, processing layer and execution layer. The perception layer is responsible for collecting the visual information of the processing process; The processing layer analyzes and processes the collected images to extract useful information; The execution layer adjusts the motion control parameters according to the processing results to achieve accurate control of the processing process[2].

3.1 Image Acquisition Module

Image acquisition module is the most important part of the whole system design and implementation. The image acquisition module has always been the core part of the system processing process, and its design effect directly affects the performance and effect of the system in subsequent use. The image acquisition equipment can choose an industrial camera with higher resolution to cooperate with the corresponding lighting system to ensure that the image obtained in the image processing process is clearer, and the vertical camera is used to ensure that the field of view contains the processing workpiece and cutter head at the same time. Because there is no direct coordinate conversion relationship between the two cameras, the two cameras need to be calibrated separately before signal acquisition to obtain 3D coordinate information of the image, so as to ensure that the selection quality of tool head coordinates and tool setting distance can be improved.

3.2 Image Analysis Module

The image analysis module is the core part of the whole image processing CNC machine tool motion control system. Through image processing, analysis and positioning, and tracking the three different degrees of freedom of the tool setting point for analysis, it can realize automatic tool setting. In the process of system processing, it includes image preprocessing, image edge detection, tool setting point and tool setting distance and other different calculated images. The processing module can quickly eliminate the redundant information contained in the image, and can quickly obtain the real information of the real image, including the gray change, median filtering, image enhancement and other different steps involved in the image itself. Graying refers to converting the original color image into gray image according to the obtained image, which can quickly improve the calculation speed of the graphics in the calculation, and also can increase the speed of information extraction. Median filtering can quickly eliminate the influence of the external environment on the camera itself, do a good job of the interference of the device itself and the vibration of the lathe, and introduce the noise of the image, so as to improve the accuracy of positioning. The image enhancement step is to select the histogram equalization method and continuously expand the width of pixels, which can not only improve the quality of edge detection of the workpiece during detection, but also effectively reduce the situation of edge missing detection. In NC machining, in most cases, rectangle or circle is selected to work. This method can quickly locate the center of the workpiece and determine the tool setting point and coordinates.

3.3 Motion Control Module

The motion control module uses three servo motors in different directions to effectively control the motion direction and mode of the whole tool. Selecting the closed-loop control system mode can realize the overall control of the tool setting system. The first thing we need to do is to receive the upper computer, analyze the workpiece coordinate information, and send instructions to the motion control module within the first time. The purpose is to improve the driving effect of the servo motor. Using the transmission device to move it to the

workbench, we can realize the alignment work in three different directions, so as to ensure that the tool setting process can quickly achieve zero point return and rapid positioning, and meet the actual needs of the CNC machine tool in use. The specific coordinate position of the workpiece center should be obtained by analyzing the image, and the coordinate of the tool point should be effectively controlled. The drive motor can be rotated according to the motion control situation and the actual information of the coordinate, and the tool can be gradually moved to the top of the workpiece. It should be horizontally aligned, and then the z-axis descent distance of the control machine tool should be monitored according to the image processing requirements. The lowering of the tool should be monitored and the vertical alignment should be done to improve the use effect of the motion control module. Moreover, when selecting the motion control module, it should be clear that the focus of its design is to deeply integrate image processing and motion control. In the design of the whole system, we need to use the visual feedback closed-loop control strategy, which can feed back the processing error and workpiece position information obtained in the process of image processing in real time, do well in motion control adjustment, dynamic adjustment and dynamic processing parameter adjustment, and clarify its motion trajectory. In the design of the whole system, it also needs to integrate intelligent decision-making algorithm. According to the actual state of processing, the optimization strategy of intelligent processing is carried out according to the real-time situation to improve the processing efficiency and quality. This design method can realize the real-time monitoring of the processing process, realize intelligent and accurate management, and comprehensively and significantly improve the overall performance of the CNC machine tool in use.

In order to verify the actual effect of the system in use, a series of comparative tests were carried out on the system itself, including machining accuracy test, machining efficiency evaluation, system evaluation, stability test, etc. In the whole testing process, the machining accuracy is tested, and the standard parts are selected for processing. The differences between the traditional system and the system in shape accuracy, dimensional accuracy, surface roughness and other directions are analyzed. In order to evaluate the machining efficiency, we need to analyze the differences between the curved surface parts and the two systems, and determine the time needed to complete different tasks. System stability analysis refers to the analysis of the system operation status and the fault situation of the system in the process of use after a long time operation of the system, which can ensure that the effect of the whole system can be improved. Through a large number of data analysis, it is concluded that the CNC machine tool control system based on image processing is superior to the traditional system in all aspects. In terms of precision machining, the error of part size of the new system has been significantly reduced in the process of part processing, and the overall reduction is about 35%. The overall accuracy of the shape is increased by about 28%, and the surface roughness of the workpiece on the surface is reduced by about 42%. According to the analysis of the processing efficiency, it can be found that the overall processing time is reduced by about 25% when the complex curved surface parts are processed. Then the stability test of the system can be carried out, and it can be found that the CNC machine tool control system with image processing has no obvious performance degradation or performance failure within 48 hours of operation. This result fully shows that the selection of image processing technology can improve the machining accuracy, machining efficiency and machining stability in the use of CNC motion control system.

4. Conclusion

To sum up, the operating accuracy and efficiency of the NC machine tool itself will directly affect the accuracy of the NC machine tool in the processing of different parts. Through image processing to control the movement of CNC machine tools, the control effect can be improved. When using the system, through the three different modules of image acquisition, image analysis and motion control, the workpiece in the whole field of view can be processed, and the vertical camera is used to ensure that there are corresponding processing workpiece and cutter head in the field of view. Through the graphic analysis module, the whole processing workpiece can be automatically tracked and positioned. Using the

motion control model, the motion law of three different servo motors controlling the cutting tool can be explored. Using the simulation and test results, it can be concluded that the system has a faster control speed and ensures the accuracy in the use process.

References

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