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Research on the Design of an Automatic Measurement System for Non-standard Device Dimensions Based on Computer Vision

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Abstract

Traditional non-standard component size measurement systems not only have low efficiency but also are prone to significant errors, which is not conducive to achieving high-precision measurement and cannot meet the development needs of the industrial field. In this regard, this paper proposes an automatic measurement system for non-standard device dimensions based on computer vision. Firstly, the definition of computer vision is briefly expounded. Secondly, the key points of the design of the automatic measurement system for non-standard device dimensions are deeply studied. Finally, the system is further analyzed with the aid of cases. Based on the research results, it is found that by using computer vision, the size of non-standard devices can be automatically measured, improving the measurement efficiency and the accuracy of the measurement results. In addition, through cases, the reliability of the automatic measurement system for non-standard device dimensions based on computer vision can be effectively verified to meet the high-precision measurement requirements of non-standard device dimensions.

Keywords

Non-standard device dimensions; Automatic measurement; Computer vision

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1. Introduction

In the field of industrial production, the application of non-standard equipment has increased significantly, and its dimensional accuracy plays a crucial role in improving production quality. The measurement of the dimensions of traditional non-standard components is generally done manually, but this method not only has low efficiency but also is prone to deviations, failing to meet the demands of high-precision industrial production. To address the shortcomings of traditional measurement methods, computer vision is gradually introduced to achieve an automated measurement system and ensure the measurement accuracy of non-standard device dimensions. Meanwhile, during the design period of the

non-standard device size automatic measurement system based on computer vision, it should be carried out from the overall measurement system, measurement system hardware, measurement system software, error analysis and system testing to achieve refined design, so as to ensure the efficient and automatic completion of non-standard device size measurement tasks and meet the needs of industrial production.

2. Overview of Computer Vision

Computer Vision (CV) is an interdisciplinary technology that takes machine understanding, analysis, and interpretation of visual data as its core. Based on a large amount of data, it simulates the human visual system to achieve perception of the surrounding environment [1]. From the perspective of the size of non-standard devices, computer vision precisely captures the visual information of non-standard devices through image sensors and converts this information into digital images, thereby forming the original two-dimensional pixel matrix. Meanwhile, computer vision achieves noise suppression through preprocessing, adjusts the contrast and color, and processes filtering to enhance the image quality. Subsequently, through feature extraction algorithms, high-quality images are precisely extracted to determine the size parameters (length, width, and diameter) of non-standard devices. In addition, during the application of computer vision, with the help of pattern recognition technology, the dimensions of non-standard devices of different specifications and types can be quickly classified, and automated measurements can be carried out according to the types to ensure the accuracy of the measurement of non-standard device dimensions and meet the diverse production needs in the industrial field.

Computer vision has advantages such as non-contact measurement, high-precision measurement, and the realization of automated measurement. In terms of non-contact measurement, computer vision can effectively solve the problem of damage to non-standard components caused by contact, and can be applied to measurement environments such as high temperature and high pressure. For high-precision measurement, it can accurately identify the size information of non-standard components, ensure the accuracy of measurement results, and improve measurement efficiency. Realizing automated measurement refers to conducting measurement operations through high-precision and professional measuring tools, thereby reducing manual intervention and avoiding measurement errors.

3. Key Points of Design for an Automatic Measurement System of Non-standard Device Dimensions Based on Computer Vision

3.1. Overall measurement system

The overall measurement system is the fundamental design of the automatic measurement system for non-standard device dimensions based on computer vision, which affects the overall operational performance of the system and the realization of its functions. The overall architecture of the measurement system mainly consists of the optical system, the data acquisition and transmission system, and the data processing and control system, etc. Firstly, during the design period of the automatic measurement system for non-standard device dimensions based on computer vision, by utilizing the optical system, the acquisition of image point position information can be accurately and efficiently completed. Moreover, the data acquisition and transmission system is used to convert the image point position information into photoelectric, analog-to-digital, etc., and the converted data is transmitted. Then, the data processing and control system is employed. The displacement of the image point is precisely calculated to accurately determine the size information of the non-standard device [2].

Specifically, the optical system is the foundation of the entire measurement system and influences subsequent data acquisition. The accuracy of the analysis should be ensured by rationally selecting optical components and comprehensively considering parameters such as resolution and distortion, so as to guarantee the clarity and accuracy of image acquisition for non-standard devices. The main function of the data acquisition and transmission system is to convert and simulate the signals obtained by the optical system to form digital signals, and then transmit these data. At this stage, high-performance data acquisition cards and transmission routes can be selected, and anti-interference facilities can be set up

to reduce the generation of interference factors and ensure the integrity of the data [3]. The data processing control system mainly undertakes the responsibilities of data processing, analysis, and calculation. It uses advanced image processing algorithms, size calculation models, etc., to conduct net profit measurements on the dimensions of non-standard devices, etc., and visually present the measurement data to understand the actual situation of the dimensions of non-standard devices.

Special attention should be paid to the interface design between system modules to ensure the accuracy of data transmission. Moreover, through redundant design, fault diagnosis and fault-tolerant mechanisms, etc., the operational capacity of the non-standard component size automatic measurement system based on computer vision can be enhanced, avoiding the influence of interference on measurement results.

3.2. Measurement System Hardware

After the overall design of the measurement system is completed, it is necessary to carry out the hardware design of the measurement system. Mainly based on the principle of optical triangulation, a stable optical imaging subsystem is formed by using industrial cameras, telecontrol lenses, etc., so as to achieve high-precision identification of the size information of non-standard devices. Among them, industrial cameras feature high resolution, high frame rate and other characteristics. They can precisely identify the size image information of non-standard devices and convert the identified images into digital signals. However, telecentric lenses mainly use parallel optical paths, which can eliminate measurement errors caused by changes in viewing angles and ensure the accuracy of measurement results [4]. Meanwhile, during the hardware design of the measurement system, factors such as the light source and image acquisition card also need to be taken into account. Starting with the light source, it determines the imaging quality. Therefore, the appropriate light source should be selected based on actual needs to highlight the size characteristics of non-standard components. The acquisition card transmits the identified data to ensure its integrity.

Taking computer vision as the foundation, during the hardware design of the non-standard device size automatic measurement system, it is also necessary to pay attention to the compatibility among various components, as well as scalability and maintainability, etc. Through modular design, it is convenient to replace and audit each component to meet the requirements of non-standard device size automatic measurement. In addition, during the hardware design period, a complete fault diagnosis and fault-tolerant mechanism is constructed based on computer vision. The aim is to enable rapid location and resolution once any abnormality is detected during the operation stage of the non-standard component size automatic measurement system, avoiding negative impacts on the measurement work.

3.3. Measurement System software

In the automatic measurement of non-standard device dimensions based on computer vision, the measurement system software is mainly responsible for image processing, data analysis, size calculation, and display of measurement results, etc. It is also a key point to ensure the efficient operation of the automatic measurement system for non-standard device dimensions [5]. Based on computer vision, during the software design of the measurement system, different functional modules are divided through a modular design approach, mainly including: Data collection, preprocessing, feature extraction, and size calculation, etc., form independent modules. It should be noted that standard interfaces should be used between each module to achieve data and information interaction to ensure efficient data and information transmission. In addition, as the measurement system software also features a user interface and operation prompts and other functions, it can automatically and intelligently complete measurement tasks according to the prompts, thereby enhancing the efficiency of measuring the dimensions of non-standard components.

3.4. Error Analysis and System Testing

Error is the key factor affecting the accuracy of the measurement results of non-standard device dimensions. Therefore, during the design of the non-standard device dimension automatic measurement system based on computer vision, it is essential to pay attention to error analysis, determine the causes of measurement errors, and take reliable measures in combination with specific

causes to control measurement errors and ensure the accuracy of the non-standard device dimension automatic measurement [6]. Under normal circumstances, the reasons for errors in the automatic measurement of non-standard device dimensions based on computer vision are: optical system distortion, resolution limitations of industrial cameras, and low accuracy of image processing algorithms, etc. Based on this, high-performance industrial cameras can be selected in combination with specific requirements, and the optical system design can be optimized and the image processing algorithm improved to reduce errors.

However, system testing is to verify the accuracy of the automated measurement of non-standard device dimensions based on computer vision. During system testing, different specifications, types, etc. need to be used as test samples for non-standard device dimensions. By simulating the process production environment, the results of the automated measurement of non-standard device dimensions can be accurately verified [7]. Meanwhile, during the system testing phase, test data should be recorded in detail and compared with the actual requirements to determine if there are any errors. For the anomalies or problems existing in the system test, image processing algorithms can be selected for handling, and the optical system can be fine-tuned in combination with the actual situation to reduce the interference caused by light. In addition, during the system testing period, attention should also be paid to testing aspects such as response time and data processing to comprehensively evaluate the performance of the non-standard device size automatic measurement system based on computer vision and ensure the reliability of the system.

4. Case analysis

This article takes a representative non-standard device as an example. This non-standard device belongs to precision mechanical processing parts, with an irregular appearance and high requirements for dimensional accuracy. If the traditional manual measurement method is used to measure the diameter of the device, it is difficult to ensure the accuracy of dimensional measurement, and the measurement efficiency is also relatively low. To address the shortcomings of traditional non-standard device size measurement, computer vision is introduced to generate an automated measurement system for non-standard device sizes. According to the characteristics of non-standard devices, personalized design of the measurement system is implemented to ensure the accuracy of the measurement results.

Firstly, for the optical system, high-resolution and low-distortion optical components should be selected to accurately capture and identify the size image information of non-standard devices. Moreover, based on the size accuracy requirements of non-standard devices, the magnification and focal length of the optical system should be appropriately adjusted to ensure the clarity of the obtained size images of non-standard devices. In terms of data acquisition and transmission, industrial cameras and image acquisition cards are mainly used to achieve real-time acquisition of non-standard device size images, and then convert the images into digital signals for transmission [8]. To reduce data transmission interference, during the design of this non-standard device size automatic measurement system, filters were installed to minimize interference factors and ensure data integrity. The data processing control system processes the collected size images through image processing algorithms, size calculation models, etc., removing noise and adjusting contrast to ensure the quality of image data. By using feature extraction algorithms, the characteristics of non-standard devices are obtained, and with the aid of size calculation models, the size parameters of non-standard devices are precisely determined.

Secondly, this computer vision-based automated measurement system for non-standard device dimensions is also equipped with edge detection, template matching, and deep learning models, etc., to achieve real-time monitoring and control of non-standard device dimensions and accurately ensure the measurement results. The test results of the diameter size of this non-standard device were obtained and compared and analyzed with the manual measurement results. It was found that the accuracy of the automated measurement results has been significantly improved.

Finally, taking computer vision as the foundation, a complete automated measurement system for non-standard device dimensions is constructed, which can complete measurement tasks in a short time, and the data

Table 1. Test Results of the diameter dimensions of this non-standard device

Serial number	Diameter of non-standard device No. 1	Diameter of non-standard device No. 2	Diameter of No. 3 non-standard component
1	10.28	9.98	9.83
2	10.30	9.99	9.83
3	10.30	9.99	9.79
4	10.32	10.00	9.78
5	10.38	9.96	9.79
Average value	10.316	9.984	9.79

fluctuations of each measurement result are relatively small, ensuring the accuracy of the measurement results. According to actual needs, flexibly use optical components and adjust image processing algorithms to meet the requirements of automatic measurement of the irregular shape and size of this non-standard device. After the system design is completed, repeated tests on the system can determine that taking computer vision as the foundation, the non-standard component size automatic measurement system can effectively improve measurement efficiency, reduce errors, and provide a fundamental guarantee for the quality of industrial production.

5. Closing remarks

In conclusion, taking computer vision as the foundation and designing a reliable automatic measurement system for non-standard device dimensions can effectively enhance the accuracy of measurement results. However, due to the complex structure of the non-standard device size automatic measurement system based on computer vision, during the specific design period, it should be carried out from the overall measurement system, hardware, software, as well as error analysis and system testing, etc., to ensure the rigor of the system. In addition, this paper also verifies the non-standard device size automatic measurement system based on computer vision through cases. It is found that this system can effectively ensure the accuracy of non-standard device size measurement and meet the high-quality and high-precision production requirements in the industrial field.

Disclosure statement

The author declares no conflict of interest.

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