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Research on Defect Detection System of Electronic Components based on Machine Vision

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Abstract

Aiming at the adjustment and optimization of enterprise productivity structure, this paper proposes a research on jBZ-23-07 rotor-type oil pump intelligent assembly system based on machine vision. According to the requirements, the overall scheme design is formulated and the intelligent assembly system is decomposed into visual system, upper computer software system and other parts according to the design method of "from the whole to the part".Halcon was used to complete camera calibration and distortion correction, process part images, extract relevant features Based on shapeless multi-template matching method, and obtain attitude adjustment parameters.The image processing time of a single part is 130 ms and the position Angle error is 0.01°.The accuracy, stability and sensitivity of the algorithm recognition are verified by multi-method and multi-angle experiments.Finally, the average success rate of algorithm identification was 97.60%, 100.00 % and 98.04 %, respectively, meeting the overall design requirements and actual production requirements.

Keywords

Machine vision; Intelligent assembly; Halcon; Shaped-based.

1. Introduction

Machine vision joint robot servo control technology, applied to the automatic assembly system platform, can greatly reduce labor and cost expenditure, and improve the degree of intelligent assembly and flexible assembly feasibility.

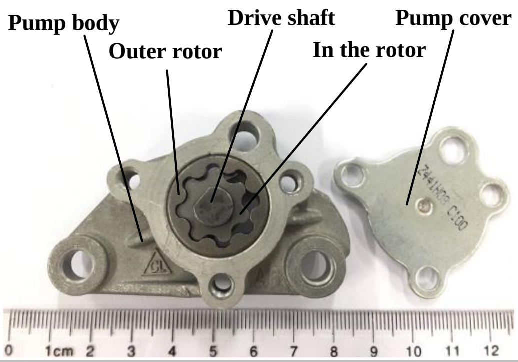

Fig 1 JBZ-23-07 oil pump

The motorcycle oil pump is a key component of the internal combustion engine lubrication system. Its function is to extract oil from the sump and pressurize the oil back to the lubricating oil channel during engine operation, so as to increase the oil pressure and ensure the continuous circulation of

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the oil in the lubrication system [1]. Rotor type oil pump shape is relatively complex, high efficiency, reliable work, long service life.

JBZ-23-07 rotor type oil pump (hereinafter referred to as "JBZ") has compact structure, small volume, light weight and large oil carrying capacity. The whole JBZ is composed of internal and external rotors, drive shaft, pump body and pump cover. Figure 1 shows the JBZ entity. The size parameters are 65 mm× 8.5mm, the number of internal rotor teeth is 7, the tooth profile is cycloid (fully known as short-amplitude external cycloid circle internal equidistance line), the number of external rotor teeth is 8, circular arc teeth.

Because oil pump, especially the motorcycle engine with this kind of mini pump, the component parts of small size and irregular shape, combined with the oil pump assembly parts between matching accuracy is higher, an oil pump manufacturing enterprise for JBZ assembly way for manual assembly, or for part of the installation process can realize the automatic assembling parts, cannot be achieved from feeding, assembling, to discharge the whole process of full automatic mode. The main reason is that the assembly system cannot realize automatic identification and positioning of the parts placed in any position, and also cannot correct the orientation of the parts to meet the needs of the installation position.

2. Overall scheme design

In order to solve the production difficulties of an enterprise, the overall design requirements of JBZ intelligent assembly system were formulated by using industrial automation control technology and combining with JBZ assembly geometric feature structure. According to the overall design requirements of the intelligent assembly system and the actual situation in the field, the intelligent assembly system is decomposed into visual system, upper computer software system, PLC control system, rotating and moving grab actuator and servo control circuit with the design method of "from whole to part". The system composition diagram of JBZ intelligent assembly system is shown in Figure 2.

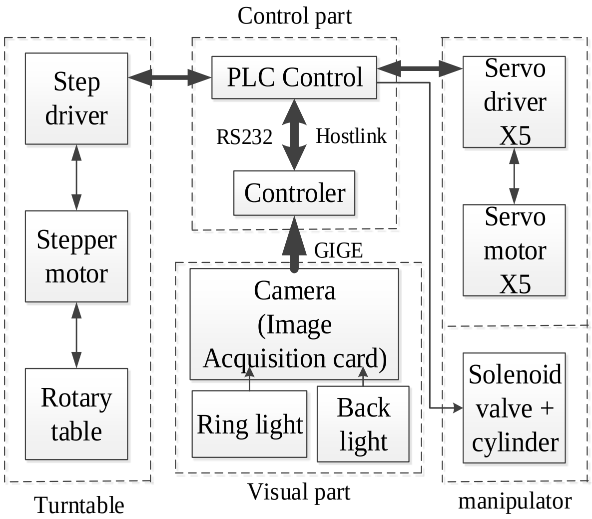

Fig 2 Composition of visual assembly system

It can be seen from the schematic diagram of the system that the rotary table part and the manipulator part are controlled by THE PLC component. The visual part mainly contains three contents :(1) graphics processing. The image collected by the camera is processed to obtain the required parameters, and the collected part images and the necessary processing results are displayed on the upper computer for output;(2) Serial communication. The parameters obtained from image processing are

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sent to the control system;(3) PLC control program. Control the actuator so that it can coordinate with each other to complete the assembly task.

The visual system adopts a single-eye CCD camera and coordinates with the backlight source and the ring light source to collect the images of the parts. The acquisition method is real-time acquisition by external trigger. The detection position and stepping rotary table are located directly below the camera for collecting the images of the parts and adjusting the positions and attitudes of the parts. In camera parts image collected and transmitted to a PC computer, image processing algorithms to identify parts and calculate the parts posture adjustment data, PC by host link communication protocol will pose adjusting data into the number of pulse stepper motor, and transmitted to the PLC corresponding address channels, through the PLC control system control step rotation detection platform position adjustment parts. In order to enable the upper three-axis manipulator to grab the parts to the assembly station, the lower two-axis manipulator needs to move the detection platform to grab the position, grab the position refers to grab the manipulator to grab the parts. When the detection platform moves to the grab position, the control system, according to the control program, controls the 3-dOF grab manipulator to move the parts to the assembly position to complete the assembly of the parts.

2.1 Visual system design

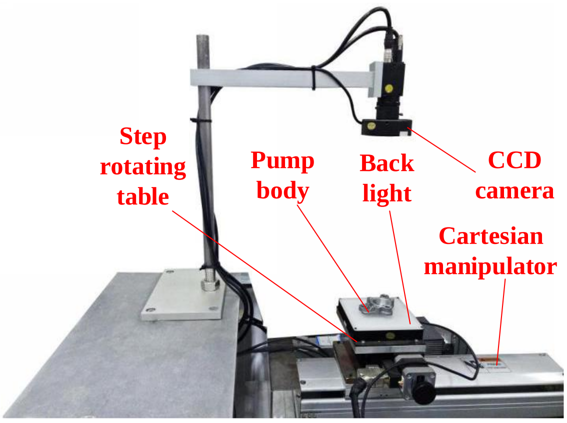

Fig 3 Visual system design platform

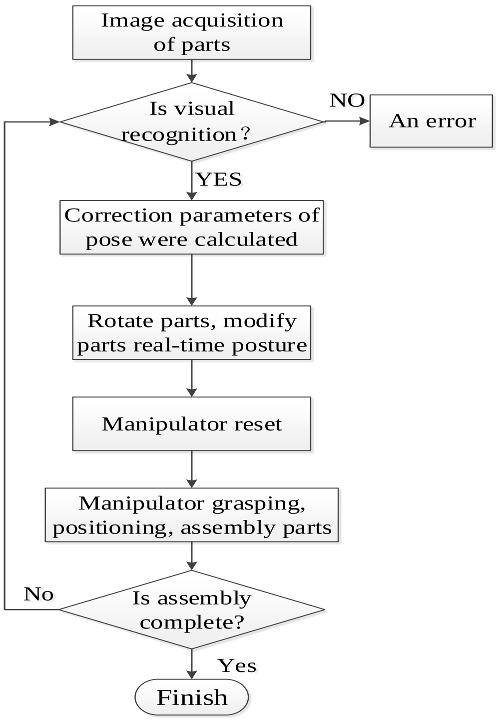

Fig 4 Specific assembly process of parts

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The visual system is the core of the overall design scheme and is responsible for collecting real-time images of parts. The image acquired requires the features of the parts to be clear and without occlusion, and the visual system to have good stability and adapt to a long time of repeated work. The visual system design platform is shown in Figure 3.

The machine vision technology is used to collect the real-time pose of the parts, and the monocular vision is used to obtain the image of the parts and the multi-template matching algorithm. The upper computer software converts the parameters into corresponding digital signals, and transmits them to the control system in a specific communication mode. At the same time, the control system controls the actuator to adjust the posture of the parts, and controls the manipulator to grab the parts and complete the whole assembly process. The upper computer displays some necessary monitoring information, such as parts acquisition images, visual recognition results, etc. The specific assembly process of the parts is shown in Figure 4.

2.2 Upper computer software system design

The upper software and PLC control program connect all parts of the system to achieve overall coordination. In general, the visual part of the upper computer software system is the main work. The image processing program has high recognition accuracy and high processing speed. Serial communication program can accurately send and receive data between upper computer and PLC;PLC control program is simple and stable, avoiding interference between programs.

PC software system human-computer interaction based on Visual Studio 2015 platform.Net architecture front-end development tools, using C# language. Visual Studio.NET provides basic functions including design, coding, compilation and debugging, database connection operation, and server component development platform based on open architecture. It involves technology and program development languages, including HTML, ASP, VBScript, JavaScript, C++, C# and so on [2].

In this paper, Halcon graphics processing software is adopted to develop the image processing part contained in the upper computer software system. By means of the joint programming of VS and Halcon, image processing and human-computer interaction are integrated to realize intelligent automatic control.

The control program of visual assembly system actuator adopts CX- Omron PLC programming software, using ladder diagram programming, at the same time of receiving the upper computer user control signal, also sends information to the actuator, connect the user with the assembly.Fig.5 shows the real-time monitoring man-machine interaction interface of JBZ pump body.

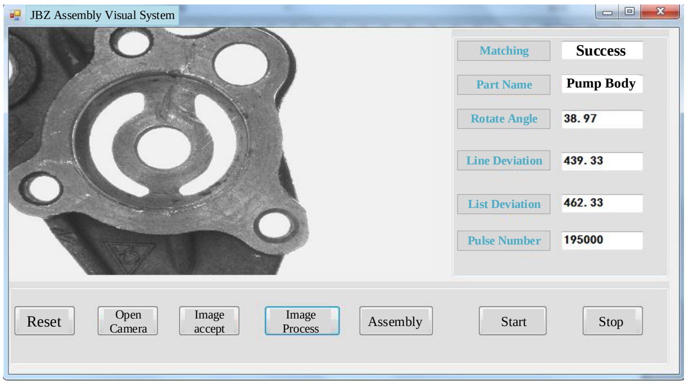

Fig 5 Human computer interface

3. Design of multi-template matching algorithm

According to the design requirements of the visual part, after the camera calibration and distortion correction, the image of parts is processed, relevant features are extracted, and pose correction

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parameters are obtained. In this paper, the shape-based multi-template matching image processing method and its implementation in Halcon are adopted.

According to different algorithms, template matching is mainly divided into matching methods based on gray scale, edge and shape [3]. Shaped Based is Halcon's shape-based template matching method in the HDevelop development environment. It mainly segmented small regions of interest from objects, and then created templates by extracting the main feature contours that can reflect the region in the ROI. Finally, matching was realized by looking for the same region in objects. According to the actual application, setting template matching parameters can significantly improve the accuracy and speed of template matching. The matching process is shown in Figure 6.

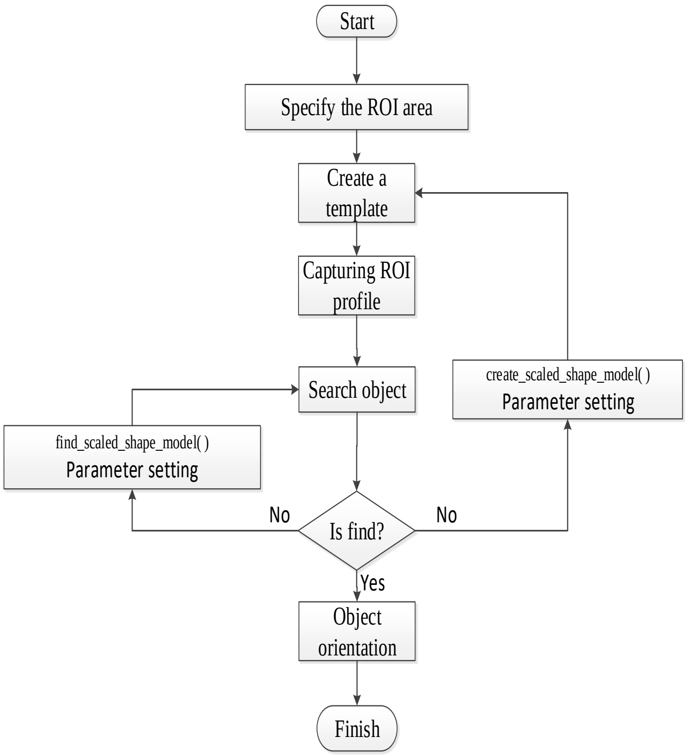

Fig 6 Matching process

In the process of template matching, different templates need to be established for the internal and external rotor, driving shaft, pump body and pump cover of the parts. According to the actual installation sequence, template matching is adopted for each installation step to obtain positioning parameters, so the shape-based multi-template matching method is needed. Taking the pump body as an example, its template and algorithm have the following steps:

(1) Determine the ROI area of the pump body image. Through multiple experiments and comparisons, the middle circle of the pump body was taken as the ROI area.

(2) Establish pump body template. Select the RIO region where the template needs to be created. According to the part characteristics, select the middle circle region to create the template, and the structural element is circular. The contour information is extracted from the image and the matching template is established.

(3) Template matching. The shape matching template can be established through the template image of the part, and the real-time image of the part can be collected for template matching to obtain the pose correction parameters.

(4) Affine transformation, matching result output. After completing part image and search matching, display the result of template matching for easy viewing and monitoring. The result of the match includes whether the match was successful and the location parameter of the match. On success, the

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matching image of the template and object is displayed, where the result of the matching image of the display template and object is displayed by translation and rotation affine transformation.

Using Halcon to perform affine transformation is equivalent to the composite operation of two translation transformations and one rotation transformation of the origin, that is, the axis (x, y) is first moved to the origin, then the rotation transformation is performed, and finally the upper left corner of the image is set as the origin. This is because in Halcon, all image processing starts at the origin, and the origin of the image defaults to the upper-left corner of the image. The translation and rotation transformation composite matrix is as follows:

$$N=\begin{bmatrix}1 & 0 & -x\\ 0 & 1 & -y\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}\cos\theta & -\sin\theta & 0\\ \sin\theta & \cos\theta & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}1 & 0 & x\\ 0 & 1 & y\\ 0 & 0 & 1\end{bmatrix}$$

The affine transformation functions of image translation and rotation can be obtained by using affine change principle and matrix operation. In Halcon, a two-dimensional affine null matrix is generated by the hom_MAT2d_identity () function, and then the template is shifted and rotated by the translation function hom_mat2d_rotate () and hom_mat2d_rotate (), so that the objects coincide with the template. The parameters of the two functions are determined by the positional offset parameters obtained by template matching, including the row and column coordinates of the position offset and the rotation Angle parameters. The final image processing result of shape-based template matching is shown in Figure 7.Shape-based multiple template matching affine change program, as shown in Figure 8.

a）Image acquisition of parts b）Template matching result

Fig 7 Image matching results and display

```
open_framegrabber ('GigEVision2', 0, 0, 0, 0, 0, 0, 'progressive', -1, 'default', -1,
grab_image_start (AcqHandle, -1)
while (true)
grab_image_async (Image1, AcqHandle, -1)
* Image Acquisition 01: Do something
dev_display (Image)
find_scaled_shape_model (Image1, ModelID, rad(-180), rad(180), 0.8, 1.0, 0.5, 0, 0.5,
if(Score>0)
 jiaodu3:=deg(Angle)$'.1f'
 disp_message (WindowHandle, '角度偏差: '+jiaodu3+'°', 'window', 12, 12, 'black', 'tru
 hom_mat2d_identity (HomMat2DIdentity)
 hom_mat2d_translate (HomMat2DIdentity, Row, Column, HomMat2DTranslate)
 hom_mat2d_rotate (HomMat2DTranslate, Angle, Row, Column, HomMat2DRotate)
 hom_mat2d_scale (HomMat2DRotate, Scale, Scale, Row, Column, HomMat2DScale)
 affine_trans_contour_xld (Model, ModelTrans, HomMat2DScale)
```

Fig 8 Shape based template matching algorithm

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After many tests, the processing time of this algorithm for a single part is 130 ms, and the position Angle error obtained is 0.01°, which meets the requirements of practical industrial use. According to the above template and algorithm features, the shape matching template is established for all other parts of JBZ. All templates are put into the file memory, and all algorithms are designed through the method of multi-template matching.

4. Verification and result analysis

The experiment is divided into three parts to verify the algorithm and analyze the results. Experiment 1: For the same type of parts (for example, all pump bodies are of the same type), multiple matching algorithms are adopted to verify the accuracy of matching algorithm for the same type of parts. Experiment 2: For the same part, change its position and Angle, and use the algorithm to repeatedly experiment on the part to verify the stability of the algorithm. Experiment 3: Randomly select various types of JBZ parts, use the algorithm to identify and calculate, and verify the sensitivity of the algorithm.

4.1 Experiment 1: Algorithm accuracy

The object is 50 JBZ parts. The 50 JBZ samples were disassembled, the parts of each pump were randomly loaded, the real-time images of each part were collected by the camera, each image was processed by the algorithm, and all the processing results were counted, as shown in Table 1 below.

Table 1 Test data of different types of parts

Part name	Number of successful matches	The success rate
Pump body	49	98 %
Outer rotor	50	100 %
In the rotor	48	96 %
Internal rotor drive shaft	49	98 %
Pump cover	48	96 %

As can be seen from the above table, the matching success rate of the algorithm for parts is high, up to 100%. After inspection, the reason for the success rate of matching between the inner rotor and pump cover parts is that the parts template contains many features, and there are defects on the surface of some parts, which can be solved by controlling the quality standard of parts. The above experiments show that the template matching algorithm based on multiple features meets the requirements.

4.2 Experiment 2: Algorithm stability

The object is different types of parts, 1 for each part. A different type of part was randomly selected from all parts, and repeated experiments were conducted for each part for 100 times. The placement and Angle of each part were randomly changed in each experiment, and the successful matching times of each part were recorded. The statistical results are shown in Table 2 below.

Table 2 Test data of the same parts of each type

Part name	Number of successful matches	Success rate
Pump body	100	100 %
Outer rotor	100	100 %
In the rotor	100	100 %
Internal rotor drive shaft	100	100 %
Pump cover	100	100 %

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As can be seen from the above table, if a part algorithm can be successfully matched, the part can be successfully matched at any position to obtain position adjustment parameters. Experimental results show that the stability of the algorithm meets the experimental requirements.

4.3 Experiment 3: Sensitivity of the algorithm

All the 200 sets of JBZ parts were randomly loaded, one part was randomly selected each time, and the image processing algorithm was used to identify and calculate the positions and poses of the parts. A total of 200 experiments were conducted, and the types and matching results of each selected part were counted, as shown in Table 3.

Table 3 Experimental data of random parts

Part name	selection times	success times	success rate
Pump body	48	47	97.9 %
Outer rotor	37	35	97.3 %
In the rotor	41	40	97.6 %
Internal rotor drive shaft	35	35	100 %
Pump cover	39	37	97.4 %

It can be seen from the above table that the matching success rate of the algorithm for each type of parts is relatively high in the process of random feeding, which indicates that the method adopted in this paper and the algorithm program written in this paper have good sensitivity and accuracy. At the same time, comparing with experiment 1, it is found that the success rate of each type of parts is very small, which also verifies the correctness of experiment 1 to some extent.

5. Conclusion

The JBZ is studied, and the overall design scheme of the assembly system is worked out according to its geometric assembly features and structure. The visual system and the upper computer software system are designed respectively. Halcon was used to collect and develop the image of parts, and the shape-based multi-template matching method was adopted. By comparing the ROI of each part with the assembly template in position and Angle, the positioning and pose adjustment parameters of parts were obtained, so as to realize the intelligent identification and orientation adjustment of parts. Using the verification experiment, stability and sensitivity to the accuracy of the algorithm to do the experiment, the results show that the visual identification algorithm for the same type parts matching the average success rate of 97.6%, the same parts repeated recognition experiment on the success rate of 100%, the same parts to change its position and Angle of the placement, the sensitive parts repeated algorithm experiment on the average value of 98.04%.Therefore, the algorithm meets the requirements in terms of matching accuracy, stability and sensitivity to multiple templates, and can meet the overall design and production requirements of intelligent assembly system.

References

[1] Zhang Wencheng, Zhou Binghai.Research on assembly Time of Oil pump for Vehicle [J]. Machinery manufacturing, 2009, 47 (542) : 8-9.

[2] Safabakhsh R, Khadivi S. Document Skew Detection Using Minimum-Area Bounding Rectangle[C]. International Conference on Information Technology: Coding & Computing. 2000.

[3] Carsten Steger, Markus Urich, Christian Wiedemann, Yang Shaorong, Wu Dijing, Duan Deshan.Machine vision Algorithm and Application [M].Beijing: Tsinghua University Press, 2008.283-316.

[4] Li Junhua, QUAN Xiao-xia. Research on multi-feature Fusion Ceramic tile Surface Defect Detection Algorithm [J]. Computer Engineering and Application, 2019.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202009_6(9).0001

[5] Li shaohui, CAI limei. Detection of seal ring defects based on multi-feature discrimination [J]. Coal mine engineering, 2015,36 (12):278-280.

[6] Shi Meihong, WANG Wenguang. Research on fabric Defect Detection Algorithm based on Blob Algorithm [J]. Modern Electronics Technology, 2010(24):28-32.

[7] Yin chunhua, Yang hongtao. Visual inspection of brake disc based on Halcon under complex background. Modern electronic technology, 2014,42(17),49-52.

[8] Gu J S, TANG L Y. Application of machine vision in Mesh Defect Detection and Classification [J]. Mechanical Design and Manufacturing, 2019(Z):47-49.

[9] Xu x y, liu y t. research on food defect detection system based on machine vision [J]. Journal of dalian nationalities university, 2019,21 (3):257-261. (in Chinese)

[10] Xu min, tang wanyou. Research on online detection of printing defects based on Blob algorithm [J]. Packaging process, 2011,9 (32):20-23.

[11] Shi Meihong, WANG Wenguang. Research on fabric Defect Detection Algorithm based on Blob Algorithm [J]. Modern Electronics Technology, 2010,(24) : 29-32.

[12] Xu yicun. Key technology for producing high-performance network transformer cores [J]. China ceramics, 2012, 48(10),49-51.

[13] URBAN S, WURSTHORN S, LEITLOFF J, et al. MuIti-Col Bundle Adjustment: A Generic Method for Pose Esti-mation, Simultaneous Self-Cslibration and Reconstruc-tion for Arbitrary MuIti-Camera Systems[J]. Intema-tional Journal of Computer Vision, 2017, 121(2): 234-252.

[14] TOULOUSE T, ROSSI L, CAMPANA A, et al. Akhloufi. Computer vision for wildfire research:An evolving image dataset for processing and analysis[J].Fire Safety Jour-nal, 2007,92:188-194.