Research on Workpiece Assembly Application Based on Machine Vision

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Abstract: A workpiece assembly system based on machine vision is designed to resolve the difficulty of manual clamp and high requirements in the industrial production line. The system applies the template matching algorithm into positioning detection of the two workpieces, automatically assemble and unload after secondary calibration. Compared with the manual operation, the system has reduced operation difficulty greatly, and the speed and repeated assembly accuracy are greatly improved, which can meet the requirements of the production line.

1. The Introduction
In recent years, with the progress of science and technology, machine vision technology has had a huge impact on both people's daily life and industrial production [1]. Machine vision is widely used in electronics, SMT, semiconductor, pharmaceutical/medical, tobacco, printing, food/beverage, automotive, lithium, photovoltaic, etc., and applications include assembly positioning, product quality testing, product identification, product size measurement, etc. The application of machine vision, replacing the artificial operation, can not only reduce the operation difficulty, improve the production efficiency, reduce the production costs, but also reduce the harm of the production environment to the human body [2]. The system applies machine vision technology to realize the automatic identification, automatic grasping and automatic welding work, reduce labor cost, reduce production difficulty and improve enterprise efficiency [3].

2. System Hardware Selection And Composition
The hardware required by the system includes light source, camera, lens, computer and so on. Light source is an important factor affecting the image quality of machine vision system, and it directly affects the quality of input data. Therefore, the light source plays a key role in the whole machine vision system. LED light source has the characteristics of fast response, long life, low power consumption and high brightness. According to the characteristics of the product and the convenience of the system design, the LED point light source is selected as the positioning and secondary calibration light source, which can meet the needs of identification. CCD camera has the advantages of high sensitivity, anti-strong light, small size, long life, anti-vibration and so on. In industrial applications, the most commonly used lenses are prime and telecentric lenses. Telecentric lens is a lens specially designed to correct the parallax of traditional lens. In a certain range of working distance, the magnification of the obtained image does not change with the change of working distance, that is, the size of the image is the same under different working distances, so it is widely used in high-precision measurement. The optical path diagram of the
telecentric lens is shown in Figure 1.

![Fig. 1 Light path diagram of telecentric lens](image)

The magnification calculation formula of the lens is shown in formula (1).

\[
\text{Magnification} = \frac{\text{Chip (horizontal direction)}}{\text{Visual field (horizontal direction)}}
\]  

(1)

According to the size and precision requirements of the tested products, 200W CCD camera and 2X telecentric lens are selected as the positioning camera. Due to the small size and higher precision requirements of the products, 500W CCD camera and 4X telecentric lens are selected for the secondary calibration position. The target surface size of the camera is 1/1.8". Advantech IPC is selected as the computer to realize image acquisition and processing as well as motion control functions of the whole system. The computer is connected with the camera through a gigabit Ethernet card to realize image acquisition and control the motion module through a motion control card. The system uses the linear module to build the motion control platform to control the clamping device and the moving camera to capture images.

3. Machine vision algorithm design

3.1 System introduction

The software of the system is programmed by Visual Studio C++ to realize the interface operation and control of the motion modules, and Halcon is used to realize the development of machine vision algorithm [4]. The workflow is shown in Figure 2. The incoming state of the workpiece is placed on the mucous membrane. The system realizes the identification of the workpiece in the incoming state and the grasping of the workpiece on the mucous membrane. The workpiece two is placed in the welding position of the workpiece one after the secondary calibration.

![Fig. 2 Working flow chart](image)
3.2 Algorithm Design

Template matching can realize integrity detection, identify the target object and obtain the position and pose of the target object in the image [5]. Template matching is divided into template matching based on grayscale. This kind of algorithm matches the original grayscale value of the image based on the template. Based on shape template matching, the algorithm has extremely high resolution in the presence of severe occlusion, confusion, or nonlinear lighting changes [6]. In practical application, a suitable matching algorithm is selected according to the characteristics of product imaging. The system uses Halcon form-based template matching to achieve workpiece positioning, welding position positioning and Angle measurement. As shown in Figure 3.

Firstly, templates are created for the workpiece to be located. Since the Angle offset of the original position of the workpiece is very small, the Angle range of the template is set to ±45° when creating the template, which not only saves the matching time, but also monitors the workpiece placed in the opposite direction. Then, the location of the workpiece is realized. For quick matching, the Angle range is set to ±45° and the MinScore is set to 0.8. If there are more than one object in the image, only find the one that is the best match. Since there is no overlap of the workpiece, MaxOverlap is set to 0. For overlap or occlusion, the corresponding value can be set according to the extent of occlusion, and the maximum value is 1. According to the value of Angle to the workpiece an offset Angle, rotate to the level after placing on the welding bench. The operator is as follows: create_shape_model (ImageReduced, 'auto', rad(-45), rad(45), 'auto', 'none', 'ignore_local_polarity', 40, 5, ModelID) find_shape_models (ImageSearch, Models, rad(-45), rad(45), 0.8, 1, 0, 'least_squares', 0, 0.9, Row, Column, Angle, Score, Model).

Figure 4 is the image of the secondary calibration position. As the size of the pattern at the bottom of the second part of the workpiece is slightly different, the above template matching may occasionally fail to match, so it can be used create scaled shape model (Image Reduced, 'auto', rad(-45), rad(45), 'auto', 0.8, 1.1, 'auto', 'none', 'ignore global polarity', 40, 10, Model ID) find scaled shape model (Image Search, Model ID, rad(-45), rad(45), 0.8, 1.1, 0.8, 1, 0, 'least_squares', 5, 0.8, Row, Column, Angle, Score, Model).
Scale, Score) To match. Parameters are basically the same as the template matching above. Scalemin and ScaleMax are the minimum and maximum range of image size scaling.

4 Conclusions
In order to effectively solve the problems of manual clamping, high labor intensity, low inspection efficiency and low assembly precision, a workpiece assembly system based on machine vision was designed. System by collecting artifacts image, using the template matching algorithm optimization, workpiece matching rate above 99.9%, and a single time of welding process in the 70s, the precision of the welding requirements to meet the needs of production line, artificial participation, only need to put up and down tray and simple computer operation, reduce the manpower cost, greatly improves the work efficiency, improve the enterprise's benefit.

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