Motor brush assembly inspection system based on OpenMV vision technology

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Abstract: Motor brush assembly inspection is an important link in the industrial field. Traditional quality inspection methods have high errors, poor efficiency and low automation. To this end, the OpenMV machine vision module is used, through the MicroPython language, combined with Canny operator and Hough Transform (Hough Transform, Hough) algorithm. A program is designed to collect the image of the motor brush and process the data by itself. After the actual application in the factory, the detection effect is good, and the accuracy rate is more than 90%, which effectively improves the detection efficiency and meets the real-time quality inspection needs of the motor brushes.

1. Introduction
As a key component in the motor, the motor brush plays a role in connecting the protection device and the rotor. However, when assembling the brushes of the motor, problems such as staggered, missing, and misplaced brushes are prone to occur. This causes the generator to be burned and scrapped, mechanical facilities are destroyed and the safety of operators is threatened\textsuperscript{1}. Qualified motor brush assembly is the key to ensuring its efficiency. Therefore, it is of great significance to study the brush assembly detection technology inside the motor.

Commonly used brush assembly detection methods include slip test method, commutator detection method, manual scribing comparison, etc\textsuperscript{2}. However, the technical requirements are low and the error is high, resulting in an increase in production costs\textsuperscript{3}.

As a new type of high-efficiency inspection technology, machine vision technology, In the detection, it has the advantages of fast response, high efficiency, no damage to the detected object, accurate detection results, etc\textsuperscript{4}. This article applies OpenMV as the underlying machine vision technology to the motor brush assembly inspection process. Three different motor brush detection methods are systematically compared with feature point recognition detection, adaptive threshold filter edge detection, and Canny operator and Hough transform hybrid detection. Choose the best method among the three different methods to improve the efficiency of motor brush assembly inspection, and effectively solve the problems existing in the current brush quality inspection methods.

2. Overview of Motor Brush Detection
The brush conducts current between the internal parts of the motor and is one of the important components of the motor\textsuperscript{5}. The brush has a slender appearance and a soft texture. It functions through
sliding contact and is widely used in various mechanical equipment.

In actual production and assembly, the workbench has a large impact force when assembling the brushes. The motor end cover is prone to jitter in the slide rail, resulting in elastic deformation, which cannot be restored, and thus causes errors\(^5\). There are 4 types of typical brush assembly errors: The distance between the brushes on both sides is too small; The distance between the brushes on both sides is too large; When the brush is inserted into the workbench, it is missing or more inserted; The brushes on both sides after insertion are not parallel and have a certain inclination angle. Qualified brushes must maintain a parallel attitude, The distance between the brushes inserted on both sides should be between 1500 ~ 2200 um.

3. Program design
The traditional inspection method is to place the brushes on the operating table uniformly after assembly. Carry out assembly line quality inspection to eliminate unqualified products. Such inspection methods are prone to human error judgments\(^6\).

In order to improve the detection effect of the system, In this paper, three monitoring schemes are designed, including feature point recognition and detection, adaptive threshold filter edge detection, and Canny operator and Hough transform hybrid detection. Contrast under the same working conditions, The difference in the final recognition effect of the motor brush assembly inspection, Therefore, the best method is selected as the main program of the OpenMV module.

4. Experiment procedure
4.1 Feature point recognition detection and results
FAST/AGAST algorithm is used to extract and identify the brush features for running the main program, and automatically draw box marks for qualified workpieces.

When the program is running, The FAST algorithm can quickly extract the corner features of the brush to be tested, and use the corners to construct a discretized Bresenlla circle. In the range of the brush image, set the threshold \(X\), the brightness value \(I\), and the parameter \(a\). Continuously select pixels whose gray value is greater than \(I \times (a) + X\) or less than \(I \times (a) - X\) as feature points, and make a designated selection. When a qualified brush feature is detected, it will automatically draw a box within the target area and output the signal result.

In order to speed up the running speed of the algorithm, the back end of the program uses the AGAST algorithm instead of a binary tree structure. Dynamically process the current image information and efficiently allocate decision trees to improve the calculation speed of the algorithm.

The result of feature point detection is shown in the figure below:

![Feature points taken](image1)

![Automatic box marking of qualified parts](image2)

4.2 Adaptive threshold filtering edge detection and results
In order to improve the overall recognition speed, reduce the frame rate and memory usage. First, the detected electric brush image is grayed out, and the edge detection is performed using the Morph transform in the MicroPython library.
The brush image is more complicated, and there are some small interlocking structures around it. Therefore, the standard etching method is not used to delete pixels. Adjust the parameters in Threshold to specify specific pixels around the corrosion brush image. Take better image effects and mark the characteristics of the brushes with identification lines. The results of filtered edge detection are as follows:

![Workpiece to be inspected](image1.png)  ![Filtered graphics](image2.png)

Figure 3 Filter edge detection interface

### 4.3 Canny operator and Hough transform hybrid detection

#### 4.3.1 Detection steps

Using the combination of Canny operator and Hough transform, through four steps. Realize the recognition and marking of the characteristic line of the brush, and finally output the judgment result.

1. **Draw the ROI area**
   - Use Gaussian filter for Canny edge detection. Calculate the gradient intensity and direction of each pixel in the brush image. Adopt Non-Maximum Suppression (NMS) suppression to eliminate spurious response caused by edge detection. Use Double-Threshold (DT) detection to determine the true edge of the brush. Extract useful structural information by suppressing isolated weak edges. Draw a region of interest (ROI) to reduce the amount of processed data.

2. **Extract brush features**
   - Hough transform is widely used in image processing as a feature extraction technology\(^7\). Through the algorithm of voting mechanism to detect objects with specific shapes. The result is determined by accumulating the local maximum value of the calculation result in the parameter space\(^8\).
   - First, pre-process the linear features of the brushes taken. Two different endpoints are randomly selected on each straight line, and the theoretical straight line equation corresponding to the current brush is calculated. Convert the extracted brush features into numerical straight lines that are easier to operate.
   - Exchange the parameters and variables in the equation to complete the point set exchange (The \(\gamma\) and \(\theta\) parameters in polar coordinates are expressed in space coordinates). First perform edge detection on the brush image. Then, under the parameter coordinates, each non-zero pixel on the brush image is transformed into a straight line.
   - Limit the Threshold threshold of Hough transform, reduce hyperparameters. Call the comparison function to selectively narrow the range of Theta_margin and Rho_margin parameters. Abandon similar line segment interference, make its performance significantly increase, reduce the generation of "false value". The recognition is more accurate, and the characteristics of the brush can be easily extracted.

3. **Data filtering**
   - Determine whether the two digitized straight lines of the identified brushes are parallel. Set up a numerical filter based on the calculated two theoretical straight lines. Compare whether the values of the slope \(k\) are equal, and make a preliminary screening judgment. Then use the distance formula...
between parallel lines to find the distance between two parallel lines.

Assign the specific distance between the two digitized straight lines to the comparison container, and compare it with the standard tolerance range of the workpiece in real time. In order to judge whether the obtained value meets the requirements. And mark the corresponding distance and the linear nature of the brush feature for the qualified workpieces. Finally, the corresponding signal is output to activate the mechanical push setting.

(4) Comprehensive gain improvement

Optimize the camera module of the main program. First, adjust the gain effect and white balance of the camera, and preprocess the image of the brush. Choose linear filtering to eliminate the problem of duplication of pixels around the brush. Overlay recursive levels to enhance the display effect of the image. Reverse the pixel value and restore the original frame number of the image after Canny edge detection. Play the role of resisting the interference of the bottom plate and surrounding light, and the image color adopts RGB565 format.

4.3.2 Test results

The program starts, and the detection interface of the hybrid detection of Canny operator and Hough transform when assembling the motor brush is as follows:

![Images](a) Qualified workpiece inspection results display  (b) Display of monitoring results for workpieces with excessively large spacing  (c) Display of monitoring results of workpieces with too small spacing

Figure 4 Program running result interface

5. Analysis of results

Use the above three different detection methods and manual quality inspection operations to conduct comparative experiments. Random sampling investigation will be conducted on the output test results of motor brush assembly conditions and the results of manual inspection of parts. Import the result data into the analysis software, and the obtained detection rate curve is as follows:
Figure 5 Comparison of three different detection methods and manual quality inspection results

It can be seen from Figure 5 that manual quality inspection is more efficient when the number of workpieces is small. But as the number increases, the accuracy fluctuations decrease. The machine vision inspection method based on OpenMV has a greater improvement than manual quality inspection in terms of automation, inspection efficiency, and accuracy.

After the number of workpieces increases, the mixed detection method of Canny operator and Hough transform is more effective than the other two detection methods. Can simplify the complex image features of the brush. And the running speed is fast, the data is stable, the program is lightweight. There will be no jams and cumbersome situations after feature point recognition and filtering detection. The recognition effect is obvious in the assembly and inspection of the brush, the accuracy is high, and the operation is stable. The error rate is effectively reduced and the production efficiency is improved.

6. Conclusion
For the inspection of motor brush assembly. The hybrid method of Canny operator and Hough transform has significant effects, and has a good response to the extraction and marking of brush images. When dealing with the complex environment in the actual brush assembly inspection, the system runs quickly and the detection effect is accurate. This method effectively avoids the tediousness and errors of manual quality inspection. Machine vision technology based on OpenMV is widely used in non-destructive testing of motor brush assembly.

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Development of Low Voltage of Brushless Motor for Air Drum(Item Number: 2018C3103)

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