Research on Rotation Angle of Faucet Detection Device Based on Image

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Abstract. In order to improve the accuracy of faucet sensitivity test and poor repeatability in the faucet detection equipment, image processing technology is applied to the faucet detection equipment for faucet auxiliary installation and its stroke angle calculation in this paper. The working principle of the rotation control device is first explained in this paper, then this paper proposes a correction scheme of the motor motion based on the image processing result, and then explains the advantages of the camera in the auxiliary installation of the faucet, and also explains the process on the calculation of the stroke angle of the faucet based on the machine vision. The actual tests show that the repeatability of the faucet sensitivity test is significantly improved.

1. Introduction
Ceramic cartridge faucets are common parts of kitchen and bathroom hardware products and are closely related to life. The valve core of a faucet is the core part, which mainly controls the water flow and regulates temperature[1]. Therefore, the internal quality of faucets product is mainly reflected in the regulation performance of the outlet water temperature and flow rate. Water faucet detection equipment[2][3], as the main test equipment faucet for product development and product quality control, should be able to provide technical support for the rapid development of the faucet industry, which has played a certain role in the specification and development of faucet products.

GB 18145-2014 "Ceramic Cartridge Faucets"[4] requests that when a predetermined speed of movement of the operating means of the handle faucets sensitivity of the assay is adjusted to 0.5°/s[5]. Error in the measurement stroke angle of conventional faucet devices is large, so that the difference of faucet handle actual speed between the national standard, resulting in the loss of the recording faucet detection reference value. In order to overcome the above disadvantages, this paper improves faucet detecting apparatus, by adding the imaging system with real-time image for the auxiliary installation of faucets, and image processing technology to calculated stroke angle of faucets to be tested, with the result of the image processing stroke motor and the speed is corrected. The actual test shows that the improved scheme proposed in this paper improves the accuracy and repeatability of the faucets detection.

2. Rotation control device

2.1. Working principle
The rotation control device in the faucet test system is mainly composed of a servo motor and a fixture for driving the handle of the water faucet. The servo motor is located at the top of the device and its
horizontal mounting position is fixed, where the fixture is connected to the motor shaft. The position of the camera is located directly below the motor, ensuring that the center of the image is aligned with the motor axis in the horizontal direction and maintains a constant relative height to the motor. The horizontal position of the faucet can be adjusted before test, and the motor and fixture and camera can be adjusted in height to achieve a suitable control position with the faucet handle. The installation position of the motor, camera and faucet is shown in figure 1 as followed.

![Figure 1. Schematic diagram of the position of the motor, camera and faucet](image)

In order to complete a sensitivity test, the faucet should be mounted on the test platform of the faucet test device. Adjust the height and position of the servo motor and the fixture so that the faucet handle can be controlled. Firstly, calculate the distance angle of the motor and faucet stroke of the image separately. Then, calculate the actual motor speed, before the fixture drives the handle to complete the test.

2.2 handle speed correction

The motor mounting position is fixed on the upper part of the device, and the fixture for rotating the faucet of the water faucet is connected with the rotating shaft of the motor. When the motor shaft drives the fixture to rotate, the handle of the faucet is rotated simultaneously. If the motor shaft and the faucet rotation center located at the same position in the ideal case, then the required angle of rotation of the motor is the maximum rotation angle of the faucet, the handle will remain consistent with the rotational speed of the motor speed. Due to the ideal situation of "concentric" in actual installation, the eccentricity between the centers of the two will cause the rotation angle and rotational angular velocity of the handle and the fixture to be out of sync. When the center of rotation of the faucet is not coincident with the axis of the motor, the measurement angle of the motor is not equal to the stroke angle of the faucet, and the rotation speed of the faucet of the faucet cannot be consistent with the rotation speed of the motor.

The stroke angle of the faucet is \( \theta \), the motor measurement angle is \( \theta_M \), the faucet handle is marked in the national standard test speed as \( v_0 \), so the rotation time of a single stroke when the faucet is tested \( t_0 = \theta / v_0 \). Since the mechanical connection between the motor fixture and the faucet handle is used, the motor is in order to make the handle, The angle of rotation is \( \theta \), the motor speed \( v_M \):

\[
v_M = \frac{\theta_M}{t_0} = \frac{v_0 \theta_M}{\theta}
\]  

(1)

In this device, \( \theta \) obtained by the camera through image processing, \( \theta_M \) calculated by the internal grating sensor of the motor, if the motor rotates at the speed \( v_M \) obtained by formula (1), turning the handle can drive the faucet to ensure its rotation and the rotation angle of the time.
3. Improvement based on image

3.1 faucet auxiliary installation
The traditional faucet testing device is designed according to the national standard. The handle operating motion device is mainly composed of a servo motor and a fixture for rotating the faucet handle. After the servo motor records the cold and hot end angles of the handle respectively, the measured water is driven by the fixture. The mouth handle is rotated to complete the sensitivity test.

Tap ideal location should be mounted immediately below the motor shaft, which is to ensure consistency between the rotational speed and the motor speed handle faucets. Due to the mechanical installation method, the motor shaft is difficult to align with the rotation center of the faucet. When the motor shaft and the faucet rotation center cannot coincide, the rotation speed of the faucet handle will deviate from the rotation speed specified by the national standard. Since the camera is mounted directly below the motor shaft, the center of the three coincide when the rotation center of the faucet is adjusted to the center of the image as viewed from the image.

When adjusting the installation position of the water faucet, firstly the relative position of the motor shaft center and the rotation center of the water faucet can be judged by the naked eye, and the coarse adjustment of the "centering" can be performed, and the position of the rotation center of the water faucet is roughly adjusted to the shaft center of the motor, and then determine the center of the image on the image and make fine adjustments. Under the condition that the camera image center has been “concentric” with the motor axis, the turret rotation center is adjusted by image assisting, and the “centering” operation is realized by using the camera as a bridge. The following figure 2 shows the actual installation when the real-time image is used to judge the faucet installation center.

![Figure 2. Spout installation screen](image)

3.2 Faucets image process
After the position among the faucet, motor and fixture is adjusted, the step of calculating the faucet stroke angle can be entered. The visual inspection system of this paper uses CMOS industrial camera[6] to image the faucet to be measured. The acquired image is digitized and input into the computer for image processing and angle measurement. In this paper, the edge detection method combining binarization preprocessing and Canny operator is used, and then the edge information is processed by Hough transform[7], and the angle of the current faucet handle is obtained. The flow of angle detection is shown in figure 3 below.

![Figure 3. Angle detection process](image)
In the actual test, the brightness of the image changes due to the ambient brightness of the faucet to be measured and the material of the housing. If a fixed threshold is used for binarization, this change cannot be accommodated. Therefore, the dynamic threshold method is adopted, and the average value of the maximum value and the minimum value of the gray value in the entire image is taken as the threshold value, and the image is binarized. Thus, even if the brightness of the surface of the faucet changes, the accuracy of the detection will not be affected, the applicability of the system is greatly improved, and the requirements for the use environment are lowered.

Hough transform can be used to detect a curve of an arbitrary shape in space. By transforming the initial image into some form, the points on the geometric curve of the given shape on the original image are transformed into some positions of the transform space after being transformed. A peak point is formed on the transform space, and the presence of the given shape curve in the original image and the corresponding position are found by detecting the peak point in the transform space. Since the Hough transform is all points on the original image is processed, taking the final combined effect, it has interference capability.

When the water faucets are at the coldest and hottest ends respectively, the cold and hot end angles in the image coordinate system are obtained by the image processing technique in the mechanical non-contact mode[8], so the difference between the two angles is the faucet stroke angle. Calculating the motor operating speed based on this angle allows the motor to complete the test in accordance with the results of the image measurement rather than the angle recorded by the motor itself.

Table 1. Calculation results of the stroke angle of a single-handle double-control faucet

| Number of measurements | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|------------------------|----|----|----|----|----|----|----|
| Measurement result (°) | 109.69 | 110.09 | 109.84 | 109.94 | 110.04 | 109.87 | 109.18 |

The actual stroke angle of the faucet is 109.5°, which shows that the method of visual inspection has good accuracy, and it can be considered that the result of the image method measurement is the actual faucet stroke angle.

4. Conclusion

This paper based on image processing faucet stroke angle measurement and a handle speed correction scheme. The actual operation proves that the method of this study is feasible, which can effectively improve the measurement accuracy of the faucet stroke angle, and can better meet the national standard sensitivity test requirements. Therefore, the research in this paper is used in the faucet detection equipment to improve the detection accuracy of the sample detection, and expand the applicable range of the sample to be tested.

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