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Reading Recognition Method of Mechanical Pointer Meter Based on Machine Vision

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Abstract

Mechanical pointer instrument is widely used in industrial production practice. Timely and accurate identification of the pointer instrument indicating information is one of important means to achieve equipment condition monitoring. A new automatic identification method of pointer instrument information is proposed in this paper by using digital image processing. In the method, image prepossessing is carried out firstly. Then the region segmentation of dial and pointer is realized by contour tracking. Meanwhile, the image transformation algorithm is used to detect the pointer orientation and obtain the straight-line position parameter of the pointer. Spacing relationships of Scale line distance relationship and instrument maximum range are determined on the basis of the existing information. Automatic reading recognition of pointer meter information is come true finally. Experiments show that the automatic reading recognition method presented is accurate, reliable and efficient.

Keywords

Pointer meter, Hough transform, Reading recognition

1. Introduction

Mechanical pointer instrument has the characteristics of simple structure, easy maintenance, low price, etc. It is widely used in the industrial production practice. It is one of the important means to obtain mechanical equipment information and realize equipment condition monitoring.

Usually, acquisition of mechanical instrument information is indicated by the pointer position or its deflection value relative to an indicator. It is obtained by manual interpretation or record transcription. The process of reading or copying is easily impacted by various subjective and objective factors, such as observation angle, technical ability, site conditions, light and some others environmental factor. Manual reading and copying is also time-consuming and laborious. And it cannot be guaranteed to be complete and accurate, easy to produce read and write errors. The results cannot obtain the change information of the operating state parameters of the machine in time and accurately.

Application of machine vision and digital image processing technology, the research of pointer meter reading method and information recognition technology has always been one of the hot issues in applied research [1], and has been successfully applied to the practice of industrial production. For example, Zhang Fengxiang et al. applied the image line detection principle to realize the reading recognition of the mechanical pointer instrument [2]. Guo Zihai et al. applied the Hough transform method to detect the position of key elements of the instrument, and the scale correlation coefficient is used to achieve reading recognition [3]. Using the silhouette method, Zhao Yanqin et al. took the instrument specifies rotation as the main element of the study, mark identification [4]. Again, F. Correa Alegria and A. Cruz Serra also use silhouettes, use the analog image overlap differential algorithm to mark the meter center, determines the recognition of the relative relationship between the mechanical pointer and tick marks, the method to realize the reading recognition [5]. Kyong-Ho Kim et al., make use of image segmentation algorithms, geometric projection technology

realizes the dial of the pointer gaugean and effective image recognition of the pointer. The German company Marr also used image processing technology to make the 875 series meter tester, it enables fast, accurate and efficient readings, however, its cost is high and it is difficult to repair.

Combined with the Hough transformation algorithm, this paper proposes a new automatic recognition method for pointer meter readings. There are three main steps: The first is image preprocessing, includes zooming and image alignment, grayscale, smooth denoising, binarization, and edge detection, improve the signal-to-noise ratio of the image. Among them, use contour tracking method to split the dial area from the pointer area, at the same time, noise reduction treatment is carried out; the second is the detection of pointer lines, including the use of morphological methods for meter pointer refinement, by using the Hough transform method, the pointer position detection and pointer direction are determined. Among them, the silhouette method was used to determine the instrument rotation center; finally, use the relationship between angle and tick marks to determine the effective range of the dashboard, completed the automatic reading recognition of the pointer meter number.

This paper the GUI platform is used to carry out relevant experimental research, and the error analysis of straight line detection and scale line coincidence was carried out, a corresponding solution is proposed to improve the detection accuracy.

The experiment completed more than 20 representative image processing and reading recognition experiments of three types of pointer instruments, the experimental results show that: The pointer meter readings obtained by applying the transformation method proposed in this paper are 20%-30% more accurate than manual reading recognition. The automatic reading recognition method proposed in this paper is more accurate and reliable and efficient readings, save time and effort, it has obvious practical significance for the condition monitoring of enterprise machinery and equipment.

2. Instrument image acquisition and Reading recognition method

This article is aimed at the actual production of pointer instruments widely used by enterprises, research on methods for reading automatic mechanical pointer meter information. On image acquisition, using an outdoor inspection robot with a fixed walking route, during inspection, the robot is at the designated station, using a camera mounted on its upper part, the pointer meter is photographed and get the image. This is shown in Figure 1. Among them, Fig. 1(a) is an ordinary pressure gauge, Figure 1(b) shows a stainless steel pressure gauge, Figure 1(c) shows the WSS gauge,

Figure 1(d) for shockproof pressure gauge, the resolution of the gauge image is 1080*1080.

(a) (b) (c) (d)

Figure 1. Various types of pointer meters used in industrial production.

It is not hard to see, the image background of the mechanical pointer instrument used in the field is complex, different light conditions, objective factors have larger effects on image quality, have great influence of artificial reading, copying instrument information. Generally when information recognition is carried out by using image processing technology, first is the image transformation, is the original image is converted into gray image; a statistical analysis of the grey value again, based on this, the binarization of grayscale images is carried out; the image processing algorithm is used to realize the area division of the pointer and dial, then apply the relevant transformation algorithm to achieve the key elements, such as pointer line and meter pointer rotation center recognition, then determine instrument dial range, finally the identification of the relevant display information is obtained. In general, when light conditions are good and no obvious change, the above image processing method is applicable. But the conditions on site are ever-changing, such as the angle of each shot of the robot, the light is too bright or dim, and the shooting is not in the same position or jitter, etc., it has an impact on the images acquired.

As shown in Figure 2, the image data of the pointer instrument mainly relies on the camera installed in the upper part of the outdoor inspection robot, the captured image of the pointer instrument is transmitted to the main control box of the robot with a four-core network cable, then the image data is transmitted back to the central control computer by wireless transmission, the background of computer. Using the pre-set calculation program, Online processing of the taken images one by one, obtain the characteristics of the main elements of the image, and realize the recognition of instrument display information.

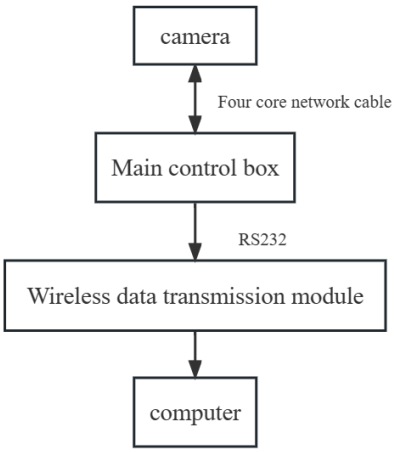


Figure 2. Overall structure block diagram of system hardware.

As shown in Figure 3 for instrument image processing flowchart, includes gauge image input, including instrument image input, scaling and primary technology such as image position adjust processing; Grey value of statistical analysis, smoothing, binarization and edge detection image processing in advance; And then to the dashboard main element of quantitative analysis, that is, pointer analysis and instrument range analysis, the former involves the refinement of the pointer, straight line detection, rotary center location and location pointer, etc., the latter mainly is the range of quantitative calculation; Finally identify instrument information.

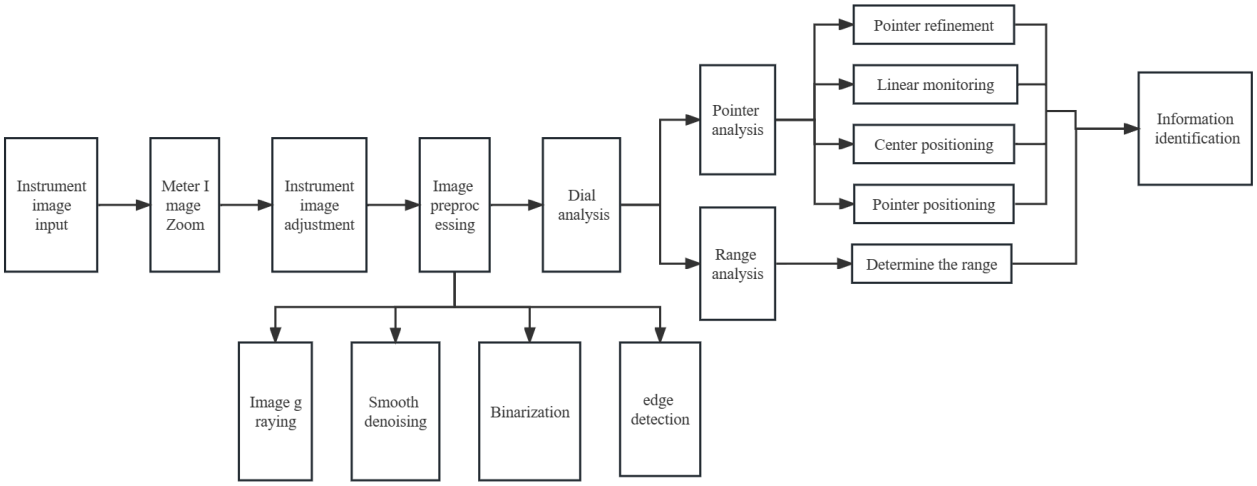


Figure 3. Instrument image processing flowchart.

3. Image processing and Feature recognition methods

After scaling and adjusting, the first step of instrument image processing is image preprocessing, that is the statistical analysis of grey value, smooth processing, binarization and edge detection. The image smooth processing goal is to remove the image noise, the method is nonlinear median filtering algorithm.

Figure 4 shows the main processes of pretreatment and the corresponding results. Figure 4(a) for the instrument, the original image; Figure 4(b) shows the image after median filtering, among them the noise points on the dashboard surface are significantly reduced; Figure 4(c) shows the processing results of binarization of instrument images; Figure 4(d) to use Canny operator for edge detection results.

After the image preprocessing is completed, carry out feature recognition of the main elements of the instrument image, includes feature parameter recognition of dial contours and instrument hands. Principle is the use of contour tracking method to trace the edge of the main element, then place the main prime edge points in order find out and paint it, finally statistical analysis. Due to the pretreatment of image elements is more, the corresponding contour areas are complex and diverse, making it more difficult to access the dial area. In this paper, main element edge tracking is realized by using the following steps.

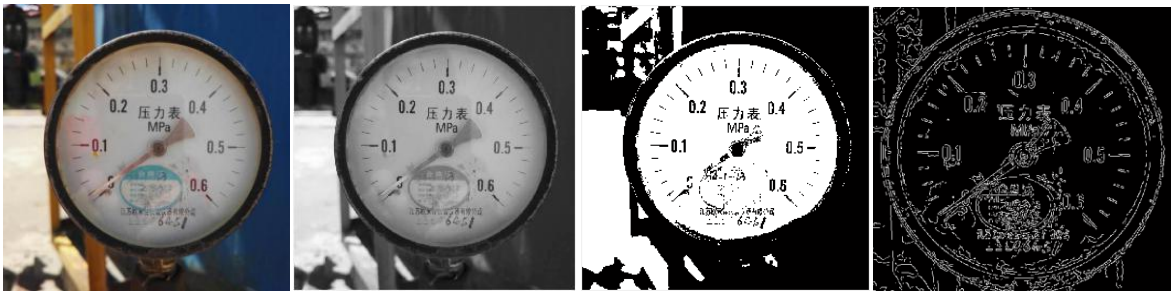
(1) Take the upper left of the image as the starting point of contour tracking, on the whole image area pixel point by

point analysis, tracking, take the effective contour that can fold back to the starting point and form a closed area, finally fill in the contour area;

(2) Follow the steps above repeatedly to find the next contour area, fill again, until the analysis and tracking of the entire instrument dial image are completed;

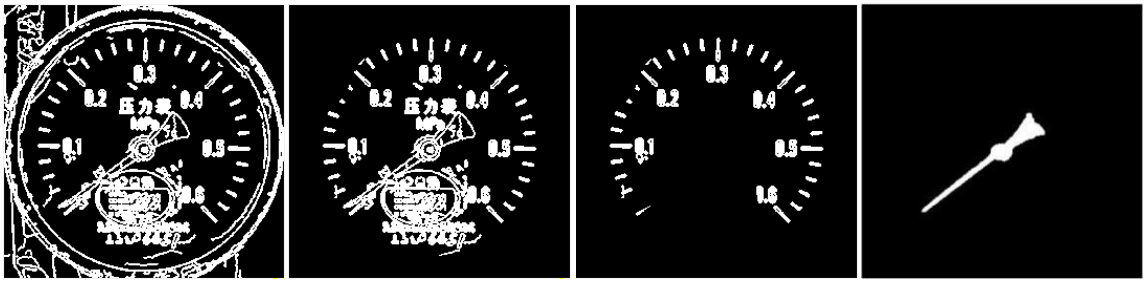
(3) Data obtained from the analysis and tracking process, binarization processing, get the whole dial area.

As shown in Fig. 5(a) and (b), is the edge image obtained after the above steps and the contour trace after filling outcome.



(a) (b) (c) (d)

Figure 4. Image pre-processing process and result.



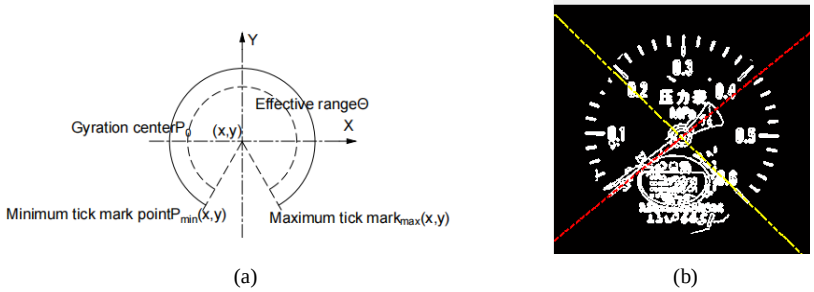
(a) (b) (c) (d)

Figure 5. Instrument dial contour tracking results.

To obtain a pointer instrument main element, that is the characteristics of the dial and hands, by the area maximization method, superimpose the original image with the processed pointer image, subtract again, eventually get the images of the main element dial and hands area, as shown in Fig. 5(c) and (d).

Generally, the main elements in pointer meters are straight lines, for example the hand lines and the short straight lines that make up the dial. Firstly, the morphological method is used to refine the instrument images shown in Fig. 5(c) and (d), then apply the Hough transform method, carry out straight line detection, transform geometry in an image into a collection of parameters.

Based on the above results, statistics the position of the center of the tick mark, that is the position of the rotary center of the dial P_o (x,y). Apply contour edge tracking to find the smallest tick mark point P_{min} (x,y), maximum tick mark point P_{max} (x,y) and effective range θ, this is shown in Figure 6(a).



(a) (b)

Figure 6. Determination and marking of the effective measuring range of the instrument.

Let θ_{min} be the minimum tick angle, θ_{max} is the maximum tick angle, ω_{min} is the minimum reading value of the meter, ω_{max} is the maximum reading values, the detected pointer line angle is θ, the indicated reading is ω_θ, according to a linear proportional relationship can work out the meter reading, as shown in the following formula.

$$\omega_\theta = \frac{\omega_{\max} - \omega_{\min}}{\theta_{\max} - \theta_{\min}}(\theta - \theta_{\min}) + \theta_{\min}$$

Apply the above reading recognition method, respectively, completed the ordinary pressure gauge, WSS instrumentation, stainless steel pressure gauge three categories a total of 20 mechanical pointer instrument image processing and reading recognition experiment. The average values of the relative error were 2.44%, 1.76% and 1.65%, respectively, the overall average relative error is 1.93%.

4. Summary

This paper takes the production of mechanical pointer instruments widely used in practice as the research object, in order to obtain the meter indication value, a series of image processing methods are proposed, including image preprocessing, dial area segmentation and feature extraction methods, instrument center determination, range recognition and reading recognition analysis and calculation. On the basis of a large number of image processing experiments, error analysis and calculation were carried out. Among them, exploiting morphological principles, the main elements of the image were refined, hough transform method is applied to implement the main element, pointer position detection and recognition; Finally, through the silhouette method to determine the instrument center, instrument reading identification completed.

The experimental results show that: The proposed mechanical pointer meter reading recognition method is applied, has a good correct recognition rate, compared with the meter value, the average recognition accuracy reaches 98.07%.

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