



Research on Embedded Recognition Technology for Pointer-Type Power Meter Images Based on Artificial Intelligence

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SUMMARY: *The pointer type instrument is simple in design and intuitive in reading, which is suitable for many occasions. Without affecting the original structure of the instrument, the automatic pointer reading based on image processing provides a good solution for the automatic upgrading of the instrument. However, due to the installation angle and height, it is more difficult to patrol, resulting in low efficiency and heavy workload. Therefore, by analyzing the status quo, recognition system and recognition content of the pointer type power instrument, this paper has constructed the image recognition system of the pointer type power instrument using the embedded system, which lays the foundation for improving the accuracy of the power instrument. The image separation effect and reading recognition effect of the embedded image recognition power meter were better than the original power meter. The image separation under embedded image recognition was 5.37% higher than the original, and the reading recognition effect was 7.27% higher than the original. In a word, image processing technology can effectively improve the accuracy of power meters.*

KEYWORDS: *Pointer Type Power Meter, Image Embedded Recognition, Image Processing, Recognition Technology*

1 Introduction

The substation has thousands of pointer meters to display the current status of the devices on the website. Most of the equipment have digital interfaces, which allow the transmission of equipment status to the control center to improve the safety and reliability of substation operation. In order to overcome the adverse effects of the inherent subjective factors of inspectors and reduce the complexity of inspection, image-based visual recognition technology has become a research hotspot in recent years.

The reading of pointer type instrument is simple and intuitive. Guo Shu-Qiang proposed a pointer type instrument recognition method, introduced super resolution technology to reconstruct the instrument image, and combined with digital feature pointer type angle to identify the instrument [1]. Based on the characteristics of the pointer area image, Zhai Xueming proposed an intelligent reading algorithm for pointer meters, which can accurately and effectively identify the readings of pointer meters [2]. Sowah Robert R developed a new algorithm using computer vision and machine learning technology and applied it to the automatic reading of analog instruments [3]. Xing H. Q built a detection method that can accurately monitor and identify instrument images in order to study the power supply of the substation [4]. Ke Jiangyan used scale invariant feature transformation method and Gaussian

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difference model for instrument positioning, and proposed the design scheme of instrument identification system [5]. Kazmierkowski Marian P built a bridge between modern power system and analog digital electronic instruments required by modern signal processing, monitoring and digital control system [6]. The above studies all described the function of the pointer instrument, but did not combine with the image processing technology.

Image recognition helps to improve the accuracy of electrical instruments. Based on the inspection robot, Huang Jian designed automatic reading systems for different types of circular analog instruments. Then he proposed a fast camera alignment algorithm based on visual servo [7]. Tian Erlin proposed an algorithm to locate the pointer by searching the minimum boundary rectangle of the pointer area, and built a reference system for reading and recognition according to its algorithm [8]. Liu Guidong used a dual image segmentation algorithm to solve the problem of roughly segmenting the structural parameters of the instrument and accurately segmenting the gray difference between the scale line and its background [9]. Dos Santos Eduardo SF proposed and implemented a vision based measurement system, which can measure and transmit the value indicated by the pointer scale indicator [10]. Kirillov Alexey G created a new software and hardware system structure, and developed a special new software system to control the system and verify the quality of the scale [11]. All the above studies have described the application of image recognition in the pointer instrument, but there are still some deficiencies in the construction of the instrument image system.

The visual recognition of pointer instruments includes preprocessing, feature extraction and character recognition, among which the preprocessing of dashboard images is the main task of this document. The backlight area feature allows easy extraction of arrow rotation centers, scale grids, and digital areas. In order to ensure the effective image preprocessing with the pointer power meter, this paper develops a clear preprocessing method that combines repetitive threshold, image separation, boundary tracking and reading recognition. The traceability foundation is also established in this paper to obtain the desired preprocessing results.

2 Identification of Pointer Type Power Meter

2.1 Development status of pointer power meter system

As shown in Figure 1, the pointer type instrument identification system is widely used in industrial identification process, featuring high reliability, small error and high efficiency. In the central stage of the system, the technologies of determining threshold iterative binarization, extracting pointer loop and boundary tracking are developed, and the existing technologies meet the system requirements. The image separation and reading recognition are divided into two stages, which are used to identify different pointer type power instrument equipment. The same technology is used to identify different equipment. Due to the difference of its structure, it cannot meet the customers' needs, so these two steps need to be modified accordingly. Therefore, there are many popular image separation and reading methods. The hardware of the recognition system includes an image collection unit and a dial checking unit [12]. The image collection unit is mainly composed of measuring instruments and cameras, and the dial inspection unit is composed of image acquisition cards, personal computers, alarm equipment, etc. Accurate reading images can be obtained by using a high-resolution camera and filling in the image window on the dial surface. In addition, the pointer recognition system can be used for automatic recognition of various pointer instruments, which has the advantages of low labor intensity, high productivity, small detection error, and

high reliability.

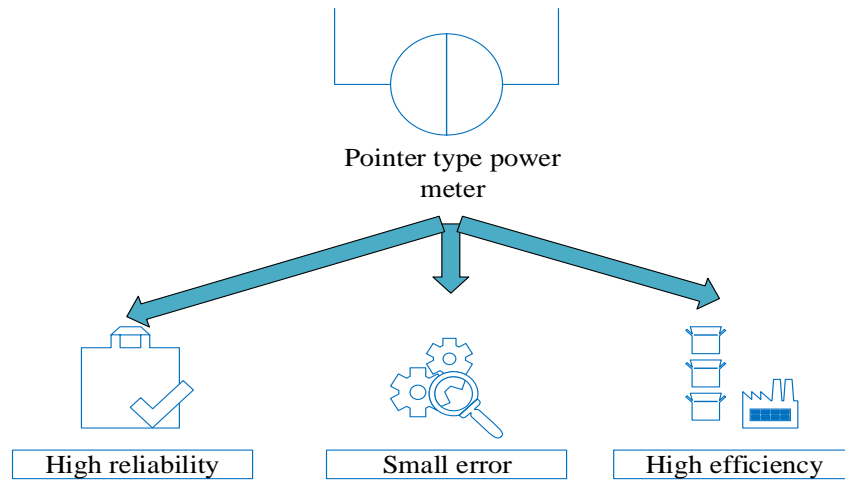


Figure 1: Characteristics of pointer instrument identification system

2.2 Analysis of image recognition system for pointer instrument

The pointer instrument recognition system mainly consists of two parts, as shown in Figure 2. The first part is the precision calibration system. In the manufacture of pointer instruments, the pointer accuracy identification system must be used to analyze the measurement accuracy to determine the applicability of pointer instruments. When making measurements, the units of measurement should be specified in this way. When designing the pointer instrument identification accuracy measurement system, it can be considered to separate the instrument from the equipment to be tested and test in the system to improve the stability and speed of the test [13]. The precision calibration system is mainly used to calculate a fixed time point, with the emphasis on eliminating image noise, extracting and detecting scaling lines and separating scaling lines by using the optical image principle. The second is the equipment maintenance system. The equipment status control system can record the changes of equipment under other operating conditions. If the quantity exceeds the rated value, different alarms are sent according to the quantity exceeded. The equipment maintenance system include both cloud platform-based system and monitoring system based on fixed time points. Among them, the cloud platform-based system is more flexible, and the pointer can still be placed in different positions even though there are many pointer instruments, effectively reducing the cost of system development, construction and maintenance.

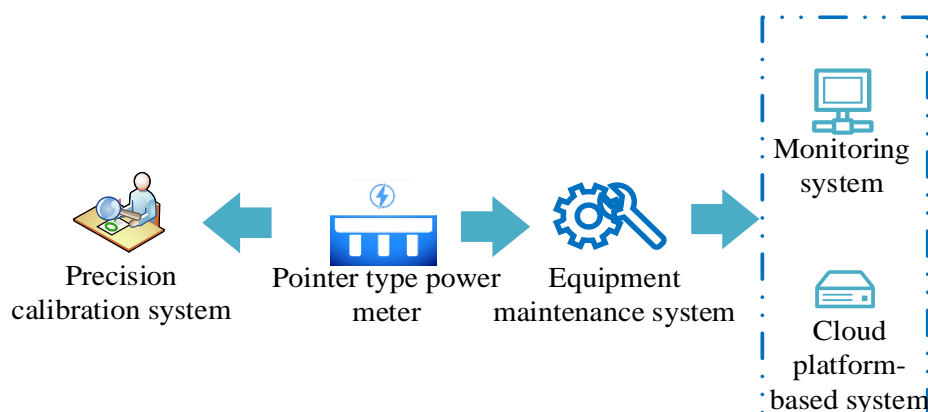


Figure 2: Composition of pointer instrument identification system

2.3 Image recognition content of pointer instrument

Only by accurately determining the direction of the pointer ruler and the instrument image can the pointer be accurately read. The specific content of the pointer instrument is shown in Figure 3. The first is pointer splitting. Pointer splitting is different from the traditional composite part, and the traditional boundary separation is used in the separation. In a specific test, due to the influence of lighting factors, the pointer in the device image is locked by the shadow, so the traditional threshold separation method cannot completely distinguish the arrow shadow. In addition, the arrow is located on the dial with tape, and there are many symbols on the board. These symbols are usually in the same position as the arrow and cannot be separated from the threshold separation method [14]. Therefore, it is more useful to define the partition boundary in the arrow part. In some applications, the deviation threshold method is used for the threshold and edge points, that is, setting the lowest threshold, the direction of the gray gradient on the upper threshold and then the lower threshold point are displayed, with little impact on the image. The second is pointer recognition. The pointer in the instrument is different from the pointer on the surface. The arrow on the dial is composed of characters, numbers, screws and other factors. It is difficult to separate the pointer of the instrument. On this basis, it can be recognized by different contour points. The third is the pointer fingertip recognition. After the pointer fingertip recognition is completed, the approximate range of the arrow can be analyzed, and the definition of the arrow edge can be retrieved using morphology.

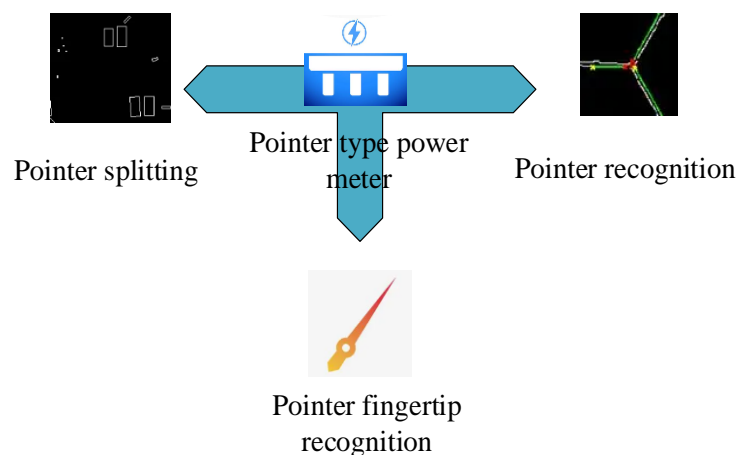


Figure 3: Image recognition content of pointer instrument

3 Image Embedded Recognition System of Pointer Type Power Meter

3.1 Application of image processing in power meter recognition

Image recognition technology is an important technology for quality recognition of indicator meters. Its detection technology is mainly used for digital image processing. During the detection process, key operations such as image acquisition, image conversion and storage, positioning and pointer recognition, gap inspection, etc. are used. The automatic management method is adopted to realize the application of analog quantity and the abandonment of inferior varieties. At the same time, the data processing function of the computer is used to

realize the automation of the whole test process of displaying, storing, querying and printing the test results report. In addition, the application of image processing technology in the electricity meter greatly improves the working efficiency of the instrument and effectively reduces the workload of the staff.

3.2 Flow analysis of embedded pointer power meter identification system

The realization method of the pointer instrument recognition system is divided into the following steps, and the whole steps are shown in Figure 4.

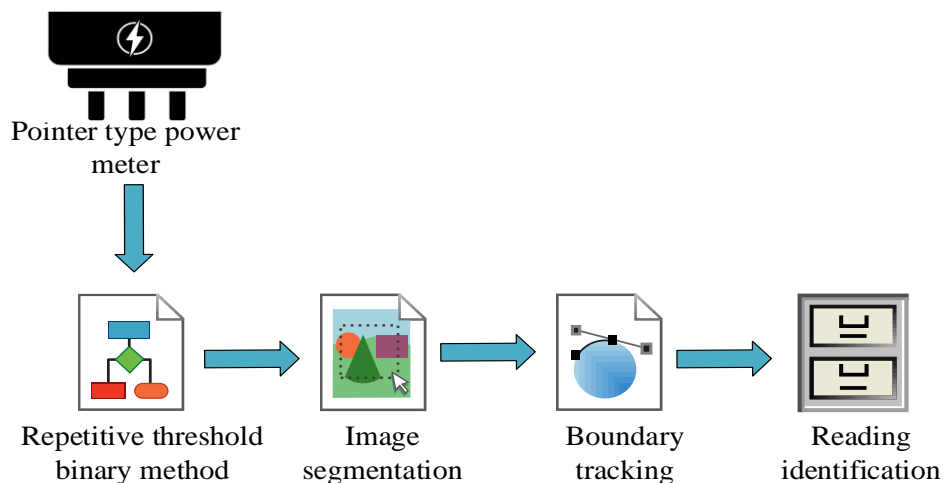


Figure 4: Flow of embedded pointer power meter identification system

1) Repetitive threshold binary method

The images on the dashboard have many binary methods, such as fixed threshold and dynamic threshold. In practical analysis, the change of image brightness depends on the ambient brightness, dial background, housing material and housing curvature. If a fixed threshold for binary processing is selected, these changes cannot be accommodated, so the dynamic threshold method is usually used as the threshold, and the maximum gray level and the minimum gray level average value of the entire image are regarded as the binary of the image processing threshold. Therefore, even if the brightness of a specific situation changes, it may not affect the accuracy of interpretation, which greatly improves the availability of the system and reduces the requirements for the environment.

2) Image segmentation

According to the attributes of an image, there are usually three main characteristics of image partitioning. The first is global image segmentation, which often requires the use of global information, such as image histograms, to share image based global information. If the image content is relatively simple, or the noise of the image source can be ignored, the gray threshold between the two peaks of the histogram can be used to distinguish the image object and the background image. The second is the edge division, which usually depends on the edge of the image. The edge detection definition is used to create the boundary of high image filter. Once the boundary is detected, the boundary is to be merged into a boundary chain through additional processing, and then grouped according to the image, and only the boundary part corresponding to the existing object or image may be displayed. Then there is region segmentation. Generally, different image regions correspond to different objects. When it is easier to segment the image content into parts or the image light field noise can be ignored, the separation technology based on the global image information can be used. In the case that the light source noise cannot be ignored, image edge separation is useful and the

partition method is suitable for the separation of target regions.

3) Automatic analysis of pointer reading

The algorithms used for automatic pointer reading include Hough transform and distance measurement. Hough transform can detect not only first-order linear objects of curves, but also objects that meet the analysis formula $f(x, c)=0$ of different analytic expressions of circles, ellipses and other recognizable higher curves. It can also calculate them through geometric series, but the amount of calculation increases a series of analytical formulas. In order to solve the defect of Hough transform algorithm, the standard Hough transform algorithm is improved, and the double threshold method is used to reduce the string error. The peak value of the conversion space is defined not only by the counter threshold value, but also by the angle threshold value to reduce the number of pixels calculated according to the characteristics of the control panel. This algorithm reduces the memory consumption of Hough transform and improves the operation speed. The distance measurement method is used to identify readings according to the requirements of the algorithm. The first tick mark on the left side of the arrow and the arrow must be coordinated with the least square method. Curve fitting changes a group of boundary points marked by the left ruler of the pointer, so the distance between the coordinate point and the curve is the minimum, and the average error of fitting is the minimum.

3.3 Scale line recognition method of power instrument based on embedded recognition technology

The identification of instrument scale line is also an important part when using pointer type power instrument for measurement. If the angle and direction of the pointer are known, dashboard grid recognition can be divided into two types. The first method is to use the closing angle scale to calculate the total number of stairs. The second step is to analyze the angle of the device, compare the angle of the pointer with other angles, and determine the position of the pointer. There are two ways of image segmentation: boundary segmentation and partition segmentation. The boundary segmentation can be used to analyze the contour of the edge, and the boundary based method can be used to obtain the complete boundary [15]. The partition segmentation method allows to obtain a closed boundary that affects the separation effect by selecting image threshold and noise limit. When thinning an image, the continuity of the bones must be ensured. By optimizing the size of the scale circle, the digital image line is simplified into simple data and structure, and duplicate information is divided in detail. The image thinning ratio is not only to save bones, but also to improve the image, so that the size and shape of bones match the image. To set the algorithm for image thinning, target binding must be provided and pixels must be deleted after changing the connection. Therefore, the overall situation of the image must be analyzed and considered, and more attention should be paid to the impact of noise on the image when the image is thinned. If there are noise waves in the image, they can be saved during the thinning process without affecting the refined pixels; if the impact of noise on the image cannot be determined, the noise must be deleted.

4 Application of Image Preprocessing in Pointer Type Power Meter

In order to study the image threshold of the pointer power meter, this paper analyzes the image change trend of the pointer power meter through image preprocessing, and analyzes the parameters according to the image change. First, the linearization processing scheme A of the

pointer type power meter is studied by using image graying:

$$A = \alpha_1 r + \alpha_2 s + \alpha_3 t \quad (1)$$

In Formula 1, $\alpha_1, \alpha_2, \alpha_3$ are the proportion of pixel gray values of r, s and t channels respectively. Then the image of the pointer power meter is processed by threshold castration, and the digital threshold of the image can be obtained as follows:

$$B(m, n) = \begin{cases} 0, & A(m, n) < R \\ 255, & A(m, n) \geq R \end{cases} \quad (2)$$

In Formula 2, $A(m, n)$ is the original image gray scale of the pointer type power meter, and $B(m, n)$ is the image threshold after castration. R is the castration threshold. Next the frequency of appearance of power meter images is analyzed as follows:

$$C(x) = \frac{1}{PQ} \sum_{A(i, j)} 1 \quad (3)$$

In Formula 3, x is the image processing level of occurrence frequency. Next, the threshold value of the electric instrument is used to determine the total number of regional pixels in the instrument, the total gray value of pixels in the background area, and the average gray value of all images as follows:

$$Q_0(y) = PQ \sum_{0 \leq i \leq x} C(i) \quad (4)$$

$$\delta_1(y) = \sum_{0 \leq i \leq x-1} i C(i) / \alpha_1(y) \quad (5)$$

$$\delta(y) = \alpha_0(y) \delta_0(y) + \alpha_1(y) \delta_1(y) \quad (6)$$

Among them, y is the initial gauge threshold. Finally, according to the mean value of the parameters, the final threshold R of the electric instrument is:

$$R = \underset{0 \leq C \leq x-1}{MAX} \left| \alpha_0(y) [\delta_0(y) - \delta]^2 + \alpha_1(y) [\delta_1(y) - \delta]^2 \right| \quad (7)$$

5 Experiment on Embedded Recognition System of Pointer Type Power Meter Image

In order to study the accuracy and speed of the recognition system of the pointer type power meter, this paper grays the image of the pointer type power meter through image preprocessing, and divides and refines the image according to the grayed image, so as to provide the visualization of the pointer type power meter and reduce the difficulty of the meter reading for patrol inspectors. First, the satisfactory results of the electric instrument patrol inspectors in three regions were investigated and analyzed, including 100 people in each region, as shown in Table 1.

Table 1: Satisfaction degree of electric instrument inspectors in three regions to the image embedded system of electric instrument

	Satisfied	Common	Dissatisfied
Region 1	85	11	4
Region 2	88	7	5
Region 3	83	9	8
Total	256	27	17

According to the data surveyed in Table 1, the overall satisfaction of the patrol inspectors of electric instruments in the three regions was relatively high, with very few feeling dissatisfied. Among the three regions, region 2 had the largest number of people feeling satisfied; region 1 had the largest number of people feeling common, and region 3 had the largest number of people feeling dissatisfied. On the whole, the number of satisfied people in the three regions accounted for about 85.3% of the total number of people; the number of satisfied people in the three regions accounted for 9% of the total number of people, and the number of satisfied people in the three regions accounted for about 5.7% of the total number of people. Inspectors feeling satisfied believed that after image recognition processing was added, the pointer type electric instrument was more accurate, and the displayed pointer image was easier to distinguish, which reduced their working pressure to a certain extent, while inspectors feeling dissatisfied felt that the image embedding system was too accurate and was likely to replace them. Then the detection error and data reliability of the pointer power meter under the embedded system were analyzed, and their changes were investigated within a week, as shown in Figure 5.

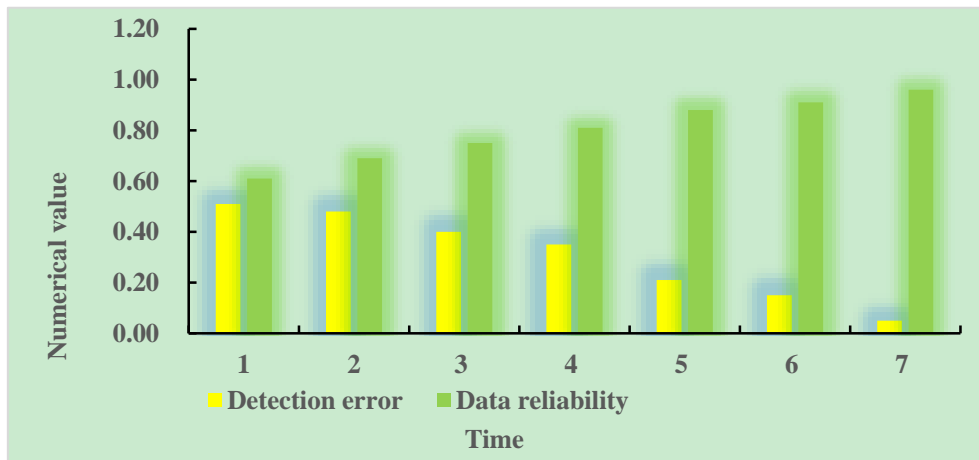


Figure 5: Changes of detection error and data reliability of pointer power meter in embedded system

According to the data investigated in Figure 5, the detection error of the pointer type power meter was decreasing over time, while the data reliability was increasing over time. The initial value of the detection error was 0.51, and finally decreased to 0.05. The initial value of data reliability was 0.61, and it finally rose to 0.96. In the whole process, the detection error decreased by 0.46 and the data reliability increased by 0.35. The decline of detection error and the rise of data reliability all indicated that image embedded technology is helpful to improve the image graying threshold of pointer type power meter, and the accuracy of pointer can be more accurate, which increases the visualization of pointer image and also reduces the detection error of power meter. Then, the final threshold value of the power meter

and the change of the average gray value of the image were analyzed by using image preprocessing. The specific changes are shown in Figure 6.

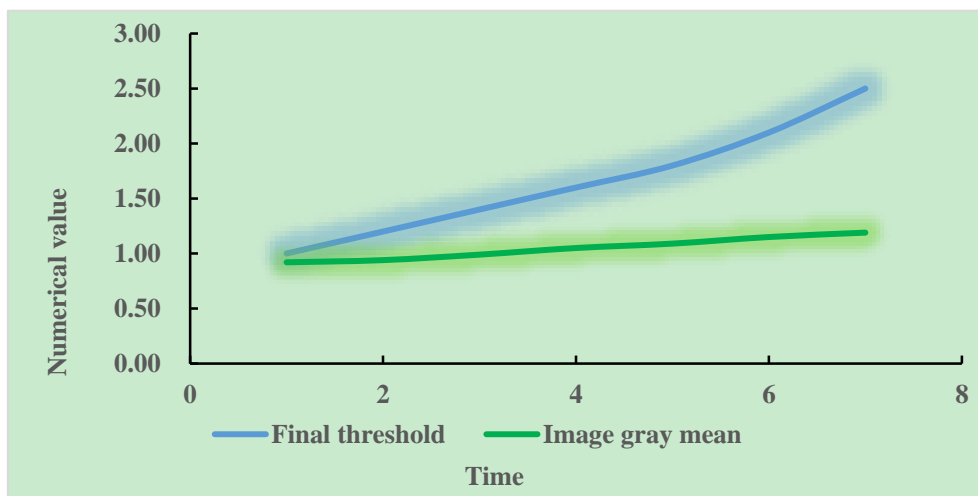


Figure 6: Changes of final threshold value of electric instrument and average gray value of image

According to the curve drawn in Figure 6, the final threshold of the power meter was rising rapidly, while the average grayscale value of the image was rising slowly. The average value of the final threshold was about 1.66, and the average value of the image graying was about 1.05. In the whole process, the final threshold value of the power meter increased by 1.5, and the average grayscale value of the image increased by 0.27. The rise of the final threshold value of the power instrument indicated that the instrument data after image processing was clearer, which not only increased its visualization, but also improved the overall background of the instrument. The slow increase of the average grayscale value of the image showed that the grayscale degree of the processed instrument data image was getting higher and higher, and the overall contour edge and pointer edge of the instrument were separated clearly, which was more convenient for the instrument patrol inspectors to read the data. Finally, the image separation effect and reading recognition effect of the power meter under embedded image processing were analyzed and compared with the original power meter, as shown in Figure 7.

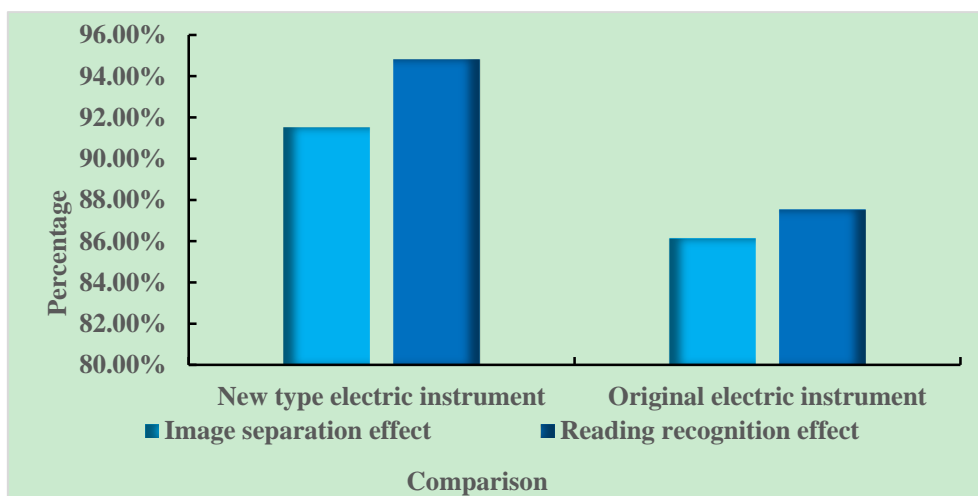


Figure 7: Comparison of image separation effect and reading recognition effect of embedded image processing and original power instrument

According to the comparison results in Figure 7, the image separation effect and reading recognition effect of the embedded image recognition power meter were better than the original power meter, and the image separation effect under the embedded image recognition was 5.37% higher than the original one, and the reading recognition effect was 7.27% higher than the original one. After embedded image recognition processing, the electric instrument could no longer be affected by the external temperature, light and noise. The specific changes of the pointer could be accurately extracted at any time, and the corresponding threshold changes could also be set for the instrument. Once the threshold change range was exceeded, an alarm could be given in time. This can reduce the work difficulty of patrol inspectors to a certain extent, improving the work efficiency of patrol inspectors. In addition, image preprocessing can also quickly grayscale the image of the power meter, which increases the visualization of the power meter.

6 Conclusions

In this paper, image processing was used to identify the image of pointer type power meter and create the image on the basis of boundary detection. Then Hough line was used to define the contour and compare with the existing design attributes to find the correct position of the pointer. Finally, the instrument readings were obtained by calculating the values. Image processing is the ability to accurately identify image data obtained from measuring instruments. This measurement method adds these parameters to the instrument structure and stores them in subsequent instrument images collected from the same location. By setting the minimum and maximum position scales of the pointer, character recognition is eliminated and the complexity of machine character recognition algorithm is reduced. Because the recognition algorithm includes prior information such as arrow length and scale width, it has good anti-interference performance. Compared with the traditional arrow recognition algorithm, it significantly improves the recognition security and accuracy.

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