Arc Image Processing Based on LabVIEW

Wei CHENG¹, Li-ting MA²*, Zheng-qi WANG², Yi GUO² and Xin-cheng Li²

¹Pinggao Group Company Limited, Pingdingshan 467001, China
²School of Mechanical Engineering, Dalian Jiaotong University, Dalian 116028, China

*Corresponding author

Keywords: Image processing, LabVIEW, Arc image.

Abstract. The breaking capacity of the vacuum switch is closely related to the morphological changes of the vacuum arc. The arc arcing image is the direct basis for the change of the arc shape. How to accurately process the arc drawing image is of great significance for analyzing the arc shape change. In this paper, an arc image processing method based on virtual instrument development platform LabVIEW is designed. The NI Vision Builder AI image processing module of LabVIEW is used to accurately extract the arc shape. The key information of arc shape can be accurately extracted by the processing of arc image such as grayscale, filtering and edge extraction, and so on. The experimental results show that this method can effectively process the arc image. The experimental results can provide theoretical basis for the analysis of arc morphological changes.

Introduction

With the increase of industrial electricity consumption, China's voltage level is also developing day by day, and it also puts forward higher requirements for the reliability of power system. Vacuum switch is an important protection and control component of power system, and its breaking capacity research has attracted the attention of scholars. [1] The key problem in studying the breaking ability is how to control the evolution of the arc shape and realize the successful breaking of the vacuum switch. Therefore, the research on the morphological characteristics of the vacuum switching arc is the focus. Most scholars use high-speed camera CCD (Charge Coupled Devices) or CMOS (Complementary Metal Oxide Semiconductor) to capture the arc image in the arc combustion process, and then apply image processing technology to extract key information from the image to obtain the arc shape research scheme. [2-4]

At present, scholars have done a lot of research on arc image processing. Wang Cong [5] and other scholars used the method of morphological water segmentation to process the arc image and successfully obtained the double arc profile of the arc. But Wang Cong mentioned that The experimental method can deal with the silk-like noise in the arc image well, but it is not mentioned for other noises. Wang Jinghong [6] and other scholars have proposed an arc image processing method based on binocular stereo vision technology. Radial basis (RBF) function, Lagrange function and other mathematical models are introduced to construct a new edge detection model, which realizes arc image information detection. However, this method is only suitable for low voltage electrical switch. The function model is complicated to construct and the amount of calculation is large. Dong Huajun [7] and other scholars use CMOS camera to collect the arc image, and process the arc image based on the MATLAB development platform, and provide the basis for analyzing the arc shape through edge extraction. The algorithm uses C language programming, the programming is complicated, the operation time is long, and it is difficult to master.

In this paper, an arc image processing method based on LabVIEW is designed. Based on G language (image programming language) programming, the arc image is grayed, filtered and edge detected. On the one hand, the arc information can be collected and improved image processing accuracy, on the other hand this method saves time and simplifies the program.
Virtual Instrument Development Platform LabVIEW

LabVIEW is a graphical programming environment developed by National Instruments USA to quickly and easily create applications with professional user interfaces. Millions of engineers and scientists use LabVIEW’s visual icons and wires to develop complex measurement, testing and control system applications. LabVIEW programming has the characteristics of graphical programming and compiling, data stream or event-based programming, multi-terminal and multi-platform, and object-oriented flexibility.

The NI Vision Builder AI module is an image processing module provided by the development platform LabVIEW. This module provides image processing assistant, image filtering, grayscale distribution and other processing packages. The image processing flow of this paper is shown in Figure 1.

![Image Processing Flow Chart](image)

**Image Processing**

**Initialization**

The experimental initialization module mainly includes measurement parameter initialization, control component reset, interface data initialization, etc. Before the experiment starts, LabVIEW can automatically create a file with experimental time and data save path. All parameters are assigned to the experiment by initial setting. Parameter setting mainly includes acquisition parameters, experiment types, experimental personnel and unit information, etc. [8]. Select image processing module in experiment type.

**Arc Image Import**

The vacuum arc image is shown in Figure 2 and imported into the NI Vision Builder AI processing module as shown in Figure 3. Figure 2 shows that the arc image has uneven gray distribution, and the arc portion has high brightness and high gray value. The background part has low brightness and low gray level. With the extension of the arcing time, the gray level of the arc part changes rapidly. After 10 ms of the same pixel point, the gray value has a big jump, and the arc shape does not have a regularity. Therefore, if we want to obtain the arc information of the arc image, the anode and cathode movement state, etc., the arc image needs to be further processed.

![Arc Image](image)
![Work Interface](image)

246
Image Graying

In the NI Vision Builder AI processing module, the filtering, edge detection and other processing technologies are based on 8-bit or 16-bit images, but the imported arc image is 32-bit. Therefore, the arc image needs to be grayed before filtering and edge detection. Processing.

After entering the program, select the Vision Assistant processing package in the working interface and process the entire arc image, then enter the Vision Assistant image processing assistant package. Apply the Extract Color Planes toolkit to extract the color plane of the arc image, which is the gray image of the arc image. The resulting arc image is shown in Figure 4.

Image Filtering

During the acquisition process, the arc image is affected by the experimental conditions such as illumination, particle motion, data transmission, and pulse current. Therefore, before the edge detection, the arc image needs to be filtered.

NI Vision Builder AI processing module provides low-pass filtering, mean filtering, Gaussian filtering, median filtering and other image filtering methods. It is proved by experiments that the noise of arc image belongs to impulse noise. For this type of noise, median filtering is selected. The best effect on arc image processing is median filtering, which is a commonly used nonlinear filtering method and the most commonly used preprocessing method in image processing technology. Median filtering can effectively smooth out impulse noise and protect the sharp edges of the image, it has a good protection for the two levels of the arc image, so the processing effect is good. The arc image after the median filtering process is shown in Figure 5.

![Figure 4. Grayscale.](image1)
![Figure 5. Median filtering.](image2)

Edge Detection

The NI Vision Builder AI processing module has multiple edge detection functions such as Laplace edge detection operator, Prewitt edge detection operator, Sobel edge detection operator, and Robert edge detection operator. Among them, The characteristic of Laplace edge detection operator is that the edge detection is more continuous, accurate and clear, and the false edge is effectively avoided, therefore, this experiment uses this operator to process the arc image.

However, during the experiment, it is found that when the traditional 3×3 matrix form Laplace edge detection operator is used to process the arc image, the partial edge detection effect is not ideal, mainly because the algorithm of 3×3 matrix form is in some non-Special directions, such as the inside of the arc image, the left and right ends of the arc column, etc., because the distance from the calculation point to the center point is different, and some real edges are ignored. It is found through experiments that the Laplace edge detection operator in the form of 5×5 matrix is used for the arc. The image processing effect is the most ideal. Therefore, the Laplace edge detection operator of 5×5 matrix form is used to perform edge detection on the filtered arc image. The detection result is shown in figure 6.

Edge Fitting and Generation Test Results

According to this algorithm, Labview is used for programming. It is not an ideal experimental result to detect the upper and lower edges of the arc, as shown in Figure 6. The reason for the analysis is mainly because the metal vapor is sprayed during the burning process, that part of the contact
image will also appear arc brightness, and the test results will not be completely matched to the actual edge of the arc column. In order to make the experimental results more accurate, the straight line fitting function of Labview is used to fit the edge of the arc column. The upper and lower edge fitting results are shown in Figure 7.

After the experiment, Labview system will automatically generate the experimental report of this experiment, and store it in the default path. The content of the experiment report mainly includes: experimenter, experiment start and stop time, test parameter setting, opening time statistics, collecting picture frame number Statistics, image processing results and other information. Through the experimental report, the entire experimental process and results can be summarized.

Conclusion

Aiming at the problem of arc image processing, an image processing method based on virtual instrument development platform LabVIEW in this paper. This method can accurately process the arc image, and obtain the key information of the arc column region. The experimental results provide theoretical basis for analyzing the evolution of arc morphology. By processing the single-frame arc image, the following conclusions are drawn:

1. The vacuum arc image has a very high brightness in the arc column, and the brightness of the moving and static contacts and the background part is low. The same pixel point has a large gray value over a period of arcing time.

2. The actual edge of the arc column is not linear, and the reason is analyzed mainly for the following reasons:
   - Firstly, during the arc combustion process, the arc gap temperature rises rapidly and reaches the melting point of the contact material. After the contact material is ablated, the gap is filled by the arc, and the edge of the arc column cannot be detected by the linear type.
   - Secondly, after the surface of the contact evaporates, the metal material is affected by the bounce of the contact, making it spray around. The high gray value of the metal vapor masks the contact point of the lower gray value and the pixel of the background part. When the edge is detected, these pixels are mistaken for the edge of the arc.

3. By using the straight line fitting function of NI Vision Builder AI processing module, the detected arc column edge can be processed to remove the influence on the non-linear arc of arc column edge caused by the false edge of arc image.

Acknowledgment

This work was financially supported by China Natural Scientific Fundamental Research Foundation under Award (No. 51477023, No. 51207016) and Educational Commission of Liaoning Province of China (No. JDL2017032).
References

[1] Shu S W, Qi J J and Huang D C, Reburning characteristics of 126kV 3 fracture vacuum circuit breaker High Voltage Technology 2012, pp. 999-1005.

[2] Dong Huajun, Liao Minfu, Zou Jiyan, et al. Image Acquisition and Processing of Vacuum Switching Arc[J]. Transactions of China Electrotechnical Society, 2007, pp. 174-178.

[3] Dong Huajun, Shi Guiming, Song Chunyu, et al. Study on arc shape of short gap vacuum switch based on image sequence[J]. Journal of Vacuum Science and Technology, 2012, pp. 44-47.

[4] Dong Huajun. Study on the shape of vacuum switch arc and its plasma parameter diagnosis [D]. Dalian University of Technology, 2009.

[5] Wang Cong, MA Guo-hong, Jiang Furong, et al. DE-GMAW Arc Image Processing Based on Digital Morphology[J]. Thermal Process Technology, 2012, pp. 145-147.

[6] Wang Jinghong, Liu Jiaomin. Switching Arc Image Processing Based on Binocular Vision Technology[J]. Transactions of China Electrotechnical Society, 2011, pp. 86-91.

[7] Dong Huajun, Kong Yihan, Dong Enyuan, et al. Detection of vacuum switch opening speed based on image sequence[J]. High Voltage Engineering, 2014, pp. 2314-2320.

[8] Xiong Xianming, Zhu Wenbo, Yang Zhiwei. Design of Electrical Life Test System for Switching Electrical Contacts Based on LabVIEW[J]. Modern Electronic Technology, 2018, pp. 133-136.

[9] Zhao Yunfeng. Study on Image Processing and Anode Combustion Law of Medium Frequency Vacuum Arc[D]. Dalian University of Technology, 2017.

[10] Ju Jianwen, Dong Huajun. Application of Median Filtering Method in Vacuum Switching Arc Image Processing[J]. Reading Digest, 2015, pp. 185-186.

[11] Zheng Ying, Sun Yuhua. Improvement of Laplacian for Image Edge Detection[J]. Journal of Shenyang Jianzhu University: Nat Sci Ed, 2005, pp. 268-271.

[12] G.R. Mettam, L.B. Adams, How to prepare an electronic version of your article, in: B.S. Jones, R.Z. Smith (Eds.), Introduction to the Electronic Age, E-Publishing Inc., New York, 1999, pp. 281-304.