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Research on Infrared Image Segmentation of Electrical Equipment Based on Adaptive Ant Colony Algorithm

Yong Hou

Bengbu University, Anhui, 233030, China
aspnetcs@163.com

Carry out research on infrared image segmentation of electrical equipment on the basis of adaptive ant colony algorithm. Adopt adaptive ant colony algorithm, establish data model and introduce infrared image technology to carry out research on segmentation of electrical equipment. **I**t can be used to find out the fault timely and accurately, provide reliable basis for preparing corresponding measures afterwards, and accelerate the operation time for recovering power grid back to normal. **I**t provides reliable basis for improving the safety performance of electrical equipment, and is worth of being generalized and applied.

1. Introduction

In the environment with rapid socio-economic development, people's demand on electric power has been increasing greatly, and domestic electric power system represents a development tendency of strong and intelligent power grid with HV main grid structure and mutual coordination among power grids at all levels; therefore, "self-healing" has become one of the main and basic features of intelligent power grid."Self-healing" indicates that when a fault or potential hazard occurs to the power grid, it could realize automatic and rapid isolation of fault and recover power supply to the whole area under the circumstance of unmanned operation. Moreover, the self-healing is also reflected in perspectives of online monitoring and safety alarm of power grid. It has been one of the keys to discover fault and take effective measures. Recovering sound operation, reducing or even eliminating the occurrence of accidents is core contents of intelligent power grid. If the electrical equipment is in abnormal heating condition for long time, creep problem will incur to the interior metal components; meanwhile, the aging and degradation problem of insulating materials will be obvious gradually, thus accelerating the damage of electrical equipment, and finally affecting the normal operation of entire power grid. With the rapid development of information technology and digital technology in recent years, infrared detection technology has been widely applied to online monitoring of electric power system due to its advantages of accurate judgment, high safety performance, easy operation, non-contact feature and quick response, etc. Moreover, the practice has proven its excellent application effect. Therefore, adopting adaptive ant colony algorithm method in the process of carrying out research on segmentation of electrical equipment could improve the accuracy of research data.

2. Literature review

Infrared technology was first applied to the military. In 1941, the British fleet applied the infrared night vision system to the Mediterranean battlefield, and received the infrared light through night vision to determine the target. During the Second World War, the German army also used infrared night vision to conduct night operations. Infrared thermal imaging technology is closely related to the development of modern weapon systems. Many targets are identified and tracked by infrared technology. Since then, infrared technology has gradually developed into various fields, such as medicine, forestry, aerospace, and so on, making infrared processing technology more and more mature. The infrared surface of any object will emit infrared rays under normal conditions, and the energy of infrared will increase with the increase of temperature. The infrared thermal imager can acquire the thermal infrared image of the object by receiving the thermal radiation emitted from the detected object without touching the object. At present, infrared thermal imaging technology is widely used in

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many scientific research fields: satellites, aircraft, ships, tanks, electronic circuits, composite materials detection, metal fusion welding, surface ocean thermal distribution research, heat conduction research, mechanical fault diagnosis, and so on. Image segmentation is the premise and foundation for solving all image problems. Image segmentation results directly relate to the effect of later image processing. Therefore, the segmentation of infrared images has always been a hot issue and it is of practical significance to conduct in-depth research on this subject.

The research on infrared images started earlier in foreign countries and the researches on related algorithms are relatively mature. Although the research on thermal infrared image processing algorithm started relatively late in China, it has developed rapidly in recent years. Xu and others proposed an infrared thermal image processing framework based on super pixel algorithm to realize automatic crack detection. They compared two popular super pixel algorithms and selected one of the super pixel algorithms to generate super pixels in the application. The combination features of super pixels were selected from the original gray image and high pass filter, and the fuzzy C- means clustering method was used to cluster the super pixels in order to divide the infrared thermal image (Xu et al., 2014). Zhang and so on put forward a new global compression algorithm to provide an effective way to improve the accuracy and processing speed of thermal image data. The algorithm was based on temperature attenuation and thermal image morphological features of temperature sensors. First of all, the spatial data were sorted according to the k- mean method. Then, all the typical temperature attenuation curves were fitted by classical fitting calculation. Finally, the curve fitting parameters were used as the parameters of the compression and reconstruction of the thermal image sequence, which realized the simultaneous compression of the thermal image sequence in space and time. In order to verify the proposed new algorithm, the two embedded defects samples made of different materials were used to conduct experiments. The results show that the proposed infrared image compression algorithm is an efficient and high-precision solution. Compared with traditional methods, the global compression algorithm not only has noise immunity, but also improves computation speed in several hundred times (Zhang et al., 2014).

Asada and Yoshitomi proposed a sign language animation method for skin area detection applied to infrared thermal image. In the system combined with the proposed method, the 3D CG model that corresponded to the human characteristic posture was automatically generated by the pattern recognition of the thermal image, and then the human hand in the CG model was set up. They used fuzzy algorithm and simulated annealing algorithm to further improve the position and direction of the automatic generation model (Asada and Yoshitomi, 2012). Xie et al. proposed a new infrared thermal image processing framework based on improved similarity measure fuzzy C-means clustering algorithm. The framework can detect defects in rough surface metal parts (Xie et al., 2012). Zhang et al. put forward a thermal image compression algorithm based on double exponential attenuation fitting model and differential evolution algorithm. The results and accuracy of the method were verified by experiments, and compared with the traditional methods. The fitting compression performance under the long time sequence and the improved model was studied, and the validity of the algorithm was verified by the actual thermal image sequence compression and reconstruction (Zhang et al., 2014). Wang and Quan studied the fire light in the scene image, and combined the gray morphology based second prediction difference method and the Top-HAT target detection method to obtain the thermal infrared target image. In addition, simulation experiments and in-depth study of image processing technology were carried out according to actual scene images. This effective detection and recognition algorithm was of guiding significance to optical remote sensing, target detection and fire engineering and so on (Wang and Quan, 2014). Li proposed a new counting algorithm for vehicle information in infrared thermal imaging video sequences. Firstly, the characteristics of the adjacent frames in the video sequences were analyzed, and the background information was modeled and updated according to the inter frame changes. Secondly, the background subtraction algorithm was used to extract the moving target information in the current frame, and the image segmentation of the vehicle in different lane and the divisions of the best detection area were made by the morphological method. Finally, the vehicle information detected by each vehicle was counted through the lane. The algorithm could segment the best segmented image and reduce the error rate and false detection rate to the greatest extent. At the same time, the algorithm had good detection accuracy for traffic flow statistics and vehicle classification in video sequences (Li, 2015). Dulski and Kastek studied a histogram equalization algorithm. The adaptive property of the algorithm ensured the significant improvement of image quality and the same effectiveness of target detection, and was also effective for any given thermal image, and would not cause visible image degradation in unpredictable conditions (Dulski and Kastek, 2012).

To sum up, there are few studies on infrared image segmentation using ant colony algorithm in the above researches. With the continuous progress of human society and the rapid development of science and technology, people begin to explore the mysteries of nature gradually and desire to get new inspiration from them. Experts and scholars from different disciplines learn from each other, draw lessons from each other, and infiltrate each discipline, resulting in many important algorithms, and bionics begins to rise. Bionics, represented by genetic algorithm and ant colony algorithm, has been developing rapidly in recent years. Therefore, in this

paper, the adaptive ant colony algorithm is used to study the infrared image segmentation of power machinery. It provides a reference for the application of ant colony algorithm in the field of infrared image segmentation.

3. Research method

This paper brings in adaption selection and dynamic adjustment to put forward improvement method and apply it into the issue of image segmentation by means of selecting ant colony algorithm path. The experiment result shows that this method accelerates image segmentation speed, and overcomes the earlier occurrence of stagnation behavior, which is conducive to finding a better solution, providing a more effective method for image segmentation. It performs infrared imaging to major electrical equipment with infrared thermography technology, and converts the infrared radiation sent by equipment into visible heat-distribution images, thus obtaining thermogram of equipment. Then, it is possible to judge the potential fault and defect exist in the equipment through analyzing changes of such infrared thermogram. The infrared thermography technology could be able to diagnose various external over-heating defect of equipment, such as the over-heating fault caused by poor connection or joint between conductive components; more importantly, it could also judge potential defects exist inside the equipment, such as the over-heating fault caused by poor connection or contact between conductive components, poor insulation performance or oil shortage in oil filled equipment, according to temperature distribution of equipment. Therefore, carrying out monitoring and alarm on substation via electrical equipment thermogram is of great importance for discovering potential hazard early, taking measures timely to avoid terrible consequence, and ensuring the safe operation of power grid [8].The intelligent patrol inspection and early warning system based on infrared thermography technology for electrical equipment in substation is an effective way for resolving aforementioned problems. This system is of great importance for reducing labor intensity, reducing the dependency on technicians, improving the operation effectiveness of electric power system, reducing maintenance cost, as well as ensuring the quality of electric energy and reliability of power supply. According to the problem of electrical equipment fault in substation, this paper adopts infrared thermogram of electrical equipment to intelligently detect the fault location. Combined with infrared remote vision and patrol inspection system, this method could be applied to unattended substation, and transform into “condition-based maintenance and predictive maintenance” of electrical equipment from “posterior maintenance” and “periodic maintenance” in traditional way. Developing the research and application of intelligent fault detection technology of electrical equipment could not only reduce the occurrence of accidents, but also create considerable economic benefits. The parameter values in ant colony algorithmic are $\rho = 0.9$, $Q = 100$, $\alpha = 1$, $\beta = 1$ and $r = 50$.

4. Research result and discussions

4.1 Research on adopting ant colony algorithm into the issue of image segmentation

Ant colony algorithm was invented in the early 1990s by a scholar - M. Dorigo who was inspired by the path selection mechanism during food searching process of ant colony. Specifically, individual ant releases a substance called pheromone during searching process, and this kind of pheromone is the medium for information exchange among different individual ants. These ants could select their path according to the pheromone concentration, namely, if a certain path has higher pheromone concentration, it is more likely to be selected by ants. In addition, pheromone volatilizes and its concentration decreases as the time goes by. Thus, the behavior of ant colony represents a kind of positive feedback of information. This is how individual ant selects the shortest path to the food source. The basic thought of using ant colony algorithm to complete image segmentation is regarding each pixel as an ant, and regarding the center of clustering as food, thus, the automatic food searching process of ant colony actually reflects the clustering of image pixel; therefore, the ants with similar features gather together to form the boundary. As ants complete the first searching, the pheromone concentration needs to be updated. On one hand, pheromone plays its role; on the other hand, ants release pheromone on the path after searching.

4.2 Adaption evolutionary improvement

In primitive ant colony algorithm, ants walk randomly and blindly. In cyclic search process, it is required to calculate selection probability of distance and path between each pixel and others; moreover, the system could only complete clustering process after several times of circulation, thus leading to long search time and large a amount of computation; meanwhile, it is easy to get into the stagnation problem caused by local optimum ; therefore, the primitive ant colony algorithm is unsatisfying when coming to the time and effect of large image segmentation. According to aforementioned problems, this paper puts forward to adopt ant colony algorithm based on evolutionary with adaption selection and dynamic adjustment, which, to some extent, accelerates image segmentation speed, and overcomes the earlier occurrence of stagnation behavior, being conducive to finding a better solution and providing a more effective method for image segmentation. According to the

analysis with ant colony algorithm, it is obvious that the main basis of ant colony algorithm is the combination of positive feedback principle of information and heuristic method. The ransom selection strategy adopted by algorithm prolongs the searching speed of algorithm; however, the positive feedback principle is aimed at strengthening solutions with better performance, but it would lead to earlier occurrence of stagnation problem of the algorithm. The basic thought for solution is to combine the deterministic selection and random selection, and then, adaptively adjust the probability of deterministic selection so as to improve the searching speed of algorithm during optimal solution searching process. As evolves into certain algebra, the evolutionary direction can be determined basically; at this moment, perform dynamic adjustment to pheromone on the path, shorten the distance of pheromone on the optimal and worst paths, appropriately increase the probability of random selection, improve the rate of convergence, and avoid being convergent to no-global optimal solution.

4.3 Experiment result

This experiment is performed under VC++6.0 environment by using two sets of fault images of main variable low pressure casing joints with size being 260×180 and 280×230 respectively. The segmentation results are shown in Fig.1 and 2.

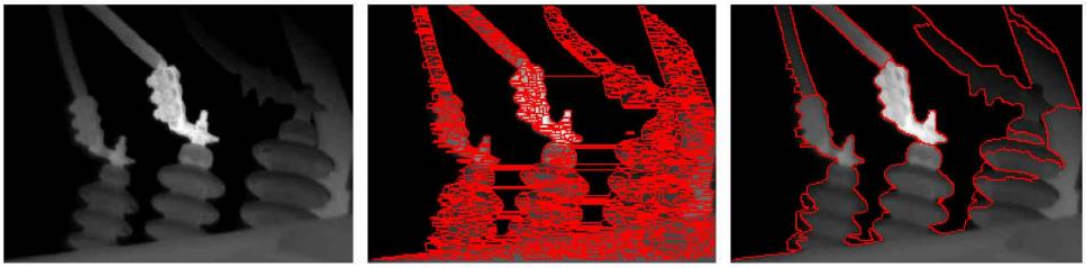

Figure 1: The result of the watershed segmentation of the main variable low pressure casing joint 1.

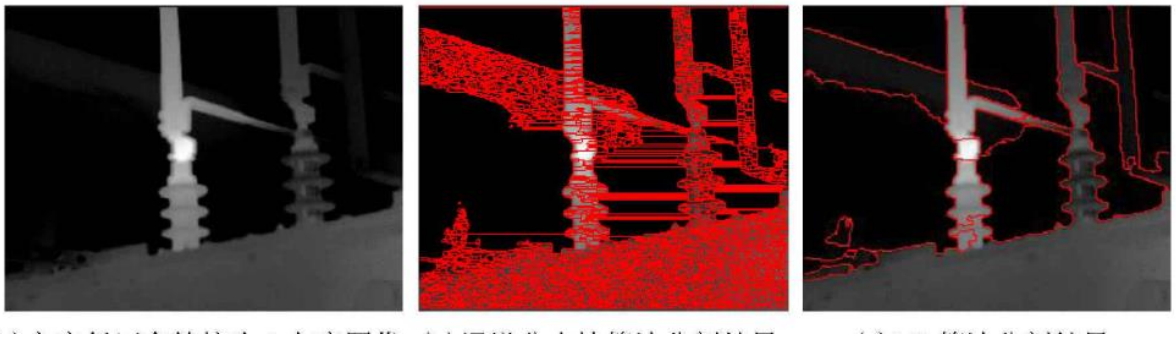

Figure 2: The result of the watershed segmentation of the main variable low pressure casing joint 2.

In the two sets of images, we aim at extracting the fault zone of joint via segmentation. The intermediate image in Fig. 1 and second image in Fig. 2 are the results of watershed algorithm segmentation, and there tremendous small zones that have serious excessive segmentation problem. The third image in Fig. 1 and third image in Fig. 2 are the results of VS algorithm segmentation. The cause for excessive segmentation is that each minimum local value in the image corresponds to a single zone, so the number of these zones is determined by that of minimum local values. The solutions for excessive segmentation should be considered from two aspects: (1) perform appropriate pretreatment before the watershed change operation, thus trying to reduce the number of extremely small local zones; (2) merge segmented zones after the watershed change operation so as to make the segmentation result more meaningful. Perform filtering and denoising to primitive images with denoising method firstly, and then, adopt VS algorithm for segmentation. After that, compare the number of segmentation zones before and after denoising, as shown in Fig. 3 and 4.

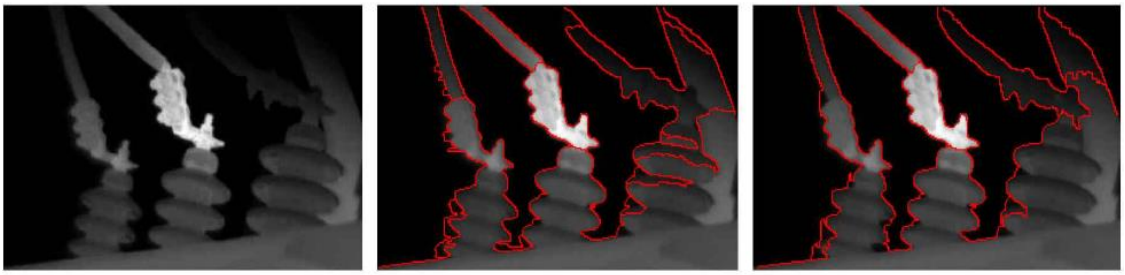

Figure 3: Primary variable low pressure casing joint 1 denoising before and after watershed segmentation results.

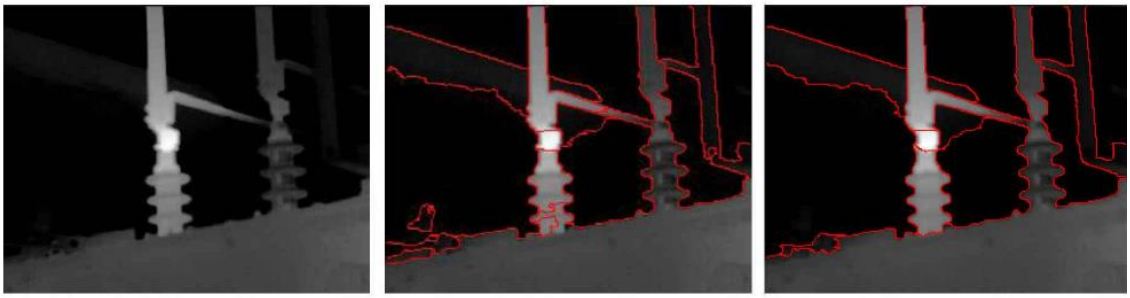

Figure 4: The main variable low pressure casing joint 2 denoising before and after watershed segmentation results.

4.4 Contrastive analysis

To verify the performance of adaption-based evolutionary ant colony algorithm in image segmentation, we need to make comparison between ant colony algorithm and aforementioned VS algorithm. Images used in the experiment include 3 types of gray-level ones: the first type contains many specifics and textures; the second type contains obvious straight lines and edges; the third type contains large flat zones, as shown in left image of Fig. 5, 6 and 7. The size of these images is 481×321, 321×481 and 321×481 respectively, namely, the three images have the same size. We use Intel Core Duo memory with 1GHz, 2G, Windows XP Professional SP2 operation system, as well as Matlab R2010a program operating software for this experiment. We extract the gray value of pixel and gradient value at the point of images. Thus, each ant is represented a bivector that consists of gray level and gradient value at the point; namely, m=2 in Formula (1). The parameter values in ant colony algorithmic are $\rho = 0.9$, $Q = 100$, $\alpha = 1$, $\beta = 1$ and $r = 50$. Where, the intermediate Figure is the handling result of ant colony algorithm, and the right Figure is the handling result of adaptive evolutionary algorithm. The Figures show that the boundary detection effect of adaptive evolutionary algorithm has been improved when compared with the primitive ant colony algorithm. Meanwhile, the average time consumption of primitive ant colony algorithm is about 5min while that of adaptive evolutionary algorithm has been reduced to half, reducing the operation time remarkably; therefore, adaption-based ant colony algorithm is obviously better than VS algorithm, and it is more applicable to electrical equipment monitoring.

5. Conclusions

According to relevant data, it is clear that at least more than 70% electrical system faults are caused by the faults of electrical equipment, and more than half of these electrical equipment faults are directly related to the heating problem caused by poor contact, loose connection, leakage flux and current leakage, etc. Therefore, it is necessary to introduce advanced scientific technologies, keep them under standard and systematic management, and eliminate dangerous points exist in equipment and system in time so as to improve the safety performance and stability of electrical equipment. This paper establishes an automatic and intelligent patrol inspection and alarm system for infrared temperature of electrical equipment by starting from the research on infrared detection and on the basis of adaptive ant colony algorithm. It also brings in advanced digital image processing technology to resolve the faults and potential safety hazards exist in electrical equipment, thus realizing automatic detection on electrical equipment faults on the basis of image segmentation. Therefore,

combining adaptive ant colony algorithm with infrared image technology during the research on improving the safety performance and stability of electrical equipment will not only detect potential safety hazards hidden inside the equipment timely and accurately, but also accuracy determine the fault location; moreover, it could also provide effective guarantee for preparing and implementing specific follow-up solutions.

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