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Research on Application of Bird Target Extraction Algorithm Based on Grey Clustering in Laser Bird Repetition of Distribution Lines

Yanbiao Wang[1,a], Ziqiang Guo[1,b*], Chengjia Bao[2,c], Meng Li[1,d], Junwu Ma[1,e]
[1.] State Grid Lanzhou Power Supply Company, Lanzhou, Gansu, 730070, China
[2.] State Grid Gansu Electric Power Company, Lanzhou, Gansu, 730070, China
[a]18794350545@163.com, [b]275785437@qq.com, [c]184566649@qq.com, [d]834350038@qq.com, [e]1961297358@qq.com

***Abstract*—With the continuous improvement of the natural ecological environment in China, the reproduction of birds is gradually accelerated. The benefits of birds to nature and human beings are well known, but the frequent activities of birds have brought some harm to the safe operation of HV transmission lines. According to the characteristics of wide field of view, long distance and low signal-to-noise ratio of targets of optical bird detection in power distribution lines, it is necessary to build a set of detection algorithm suitable for wide field of view, low signal-to-noise ratio of targets and high optical stability, so as to improve the monitoring and early warning ability of foreign flying objects in power distribution lines and ensure the safe operation of power distribution lines. In this paper, an algorithm of bird target extraction based on grey clustering is proposed to detect the target birds in the transmission line scene, and the decision threshold is used to further increase the resilience of the background complexity, thus effectively improving the bird detection rate. The experimental results show that this algorithm is more accurate in recognizing the characteristics of birds, with a 25.72% higher accuracy than the comparison algorithm, and a 17.37% higher recall rate. It can accurately locate the edge contour of birds. After many scans, radar detection can accurately detect the bird target, which is not affected by the interference of trees. This method has a wide range of bird repelling and a lasting effect, which provides an important basis for the prevention and control of bird-related faults in distribution lines.**

Keywords—Target extraction, Distribution lines, Laser bird repelling, Grey clustering

I. INTRODUCTION

With the continuous improvement of the natural ecological environment in China, the reproduction of birds is gradually accelerated. The benefits of birds to nature and human beings are well known, but the frequent activities of birds have brought certain harm to the safe operation of high-voltage transmission lines[1]. The distribution line is close to residential areas, with wide coverage and complex environment, which makes it an ideal place for birds to breed, especially in some rice, farmland, low-lying wet areas and some villages, secluded and open crop fields where birds prey, which has become a high incidence area for birds, posing a serious threat to the safe operation of the line[2]. Bird droppings flashover is easy to cause air gap flashover or pollution flashover of transmission lines, and it can be prevented by changing the size of the equalizing ring or increasing the gap between the big umbrella skirts of insulators. Birds' nesting and roosting activities above the power lines can easily lead to bird droppings flashover or interphase short circuit, which eventually leads to power failure of transmission and distribution lines[3]. At present, many kinds of intelligent bird repelling devices are used in the power sector, although they can play a certain role, but it is difficult to achieve a sustained bird repelling effect. Moreover, most of these intelligent bird repelling devices are currently applied to transmission lines above 110kV voltage level, and few bird repellers are applied to distribution lines[4]. Radar has certain advantages in bird target detection, especially when visual inspection is limited, such as at night, cloudy or snowy, radar can give full play to its superiority[5]. Even in the daytime with good weather conditions, radar can detect long-distance targets that are difficult for human eyes to observe.

The operation experience shows that the bird damage accidents on lines are on the rise year by year. Because the transmission line has a long path, many points and wide areas, the environment in the area it passes through is complex, and the remote mountainous area is an ideal place for birds to breed. Because of the strong adaptability of birds, the traditional methods of repelling and preventing birds are only effective for a period of time[6]. Generally, the power distribution line adopts the method of combining radar detection with laser driving, which can effectively drive away birds near the power distribution line and reduce aviation accidents[7]. Guo et al. put forward a bird damage assessment model for transmission lines by combining the geographical features of towers and tower structures, and through weighted quantification[8]. Zhao et al. used a digital SLR camera as a remote image sensor to capture images of migratory birds migrating in autumn in the park, and combined with threshold segmentation and region of interest division to establish a bird number matrix, so as to monitor the number of migratory birds in the park[9]. Zhao et al. detected the harmful birds in the agricultural field. Firstly, based on the Gaussian mixture model, the image background was removed and the moving birds were segmented. Then, the color features of the target objects and the median filter were used to remove the non-target objects in the images. After the preprocessing, the smallest birds were classified and detected by the neural network target classifier[10]. Li et al. put forward a method of spraying insulating coatings on the surface of capacitor bushing for bird-involved fault in converter station[11]. In this paper, an algorithm of bird target extraction based on grey clustering is proposed to detect the target birds in the transmission line scene, and the decision threshold is used to further increase the resilience of the background complexity, thus effectively improving the bird detection rate.

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II. METHODOLOGY

A. Characteristics of power distribution line laser bird repelling

The distribution line is close to residential areas, with wide coverage and complex environment, which makes it an ideal place for birds to breed, especially in some rice, farmland, low-lying wet areas and some villages and secluded and open crop fields where birds prey, which has become a high incidence area for birds, posing a serious threat to the safe operation of the line. Visual information is the physical optical image that directly or indirectly acts on human eyes, and visual cognition mainly deals with the optical image seen. Image information indirectly acting on human eyes is usually collected by various observation systems in different forms, and then displayed and acted on human eyes[12]. The power distribution line is a small overhead line, the installation height of bird repeller is not high, and the range of tower action is relatively small. Therefore, the range of laser irradiation should be limited to avoid affecting the surrounding residents, and the laser power should not be too high to reduce unnecessary power loss.

Generally, the acquisition results of optical images are stored in the form of digital signals, and these digital signals are usually expressed in the form of arrays or matrices. Each element corresponds to the feature quantity of the corresponding position in the scene. Video is composed of a group of optical images that change with time. Compared with static images, video has the greatest advantage of capturing motion information because of its strong correlation between adjacent frames. The distribution towers are relatively small, and some of them are made of cement poles, so the installation will be limited to some extent. Therefore, various methods should be adopted in structural design to adapt to different installation occasions. Before the technical processing of images, it is generally necessary to preprocess them as a standardization process. Different pre-processing methods are different for different images. The main pre-processing methods are image restoration and image enhancement.

B. Bird target extraction algorithm

Image enhancement can analyze specific image features and enhance this part to facilitate extraction. Image restoration is the restoration of images with insufficient definition or incomplete key parts. Due to the influence of the installation position, the blind area will be produced on the power distribution tower when the laser beam is irradiated. In the design, split installation or scanning of the pan-tilt control direction should be adopted to increase the irradiation range, and the blind area should be reduced as much as possible while covering the key areas[13]. As far as the absolute depth of an object is concerned, we can't shoot it with a single camera. At this time, we need to reconstruct the three-dimensional model, so that we can really see the real depth, not just the relative depth. Figure 1 shows the structure of the bird target extraction system.

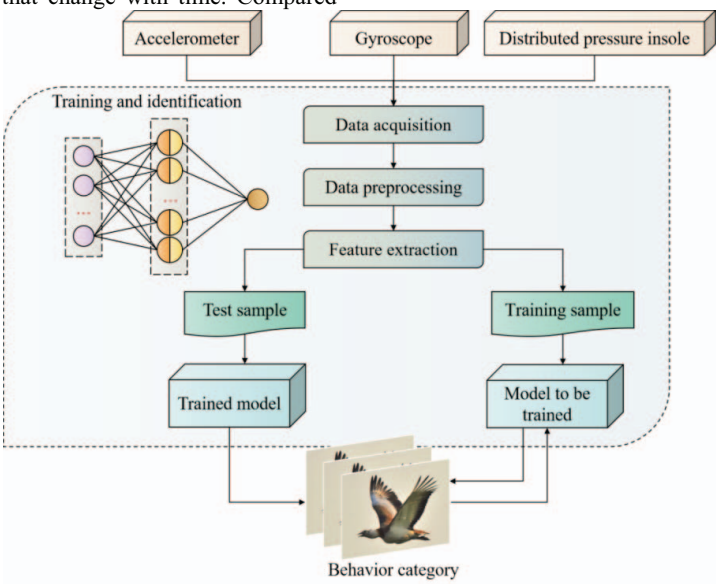

Figure 1. Structure of bird target extraction system

In bird target extraction, when a certain method has been selected to extract the shape features of images, it is necessary to determine under what conditions the two images are similar, and the most commonly used similarity measure is Euclidean distance. Euclidean distance between pattern vector and is defined as:

$$D(x,y)=|X-Y|=\sqrt{\sum_{i=1}^{n}(x_i-y_i)^2} \quad (1)$$

Where n is the dimension of the feature space. Obviously, if the samples X and Y are located in the same type area, the Euclidean distance is relatively small. If they are located in different types of areas, the Euclidean distance is relatively large.

When a bird partially enters the visual field, the characteristic information at this time is different from that when a bird completely enters the visual field. Let the width of the image be $width$, the height be $height$, the width of the minimum circumscribed rectangular frame be

$rect\_width$, the height be $rect\_height$, the center be $center$, and the error redundancy be $edge$, then the horizontal and vertical discrimination formulas are:

$$edge+\frac{rect\_width}{2} < center.x < width-edge-\frac{width}{2} \quad (2)$$

$$edge+\frac{rect\_height}{2} < center.y < height-edge-\frac{width}{2} \quad (3)$$

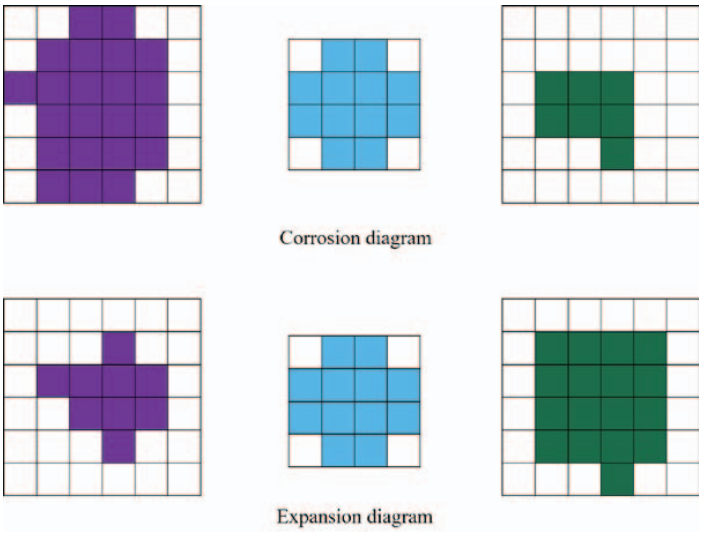

Figure 2. Schematic diagram of corrosion and expansion in Wushu bird tracking

The data access layer covers all the basic information in the database of agricultural intelligent bird repelling system, mainly including the basic characteristic information of birds, ultrasonic wave band information, etc. It will provide basic data guarantee for each function operation and mutual cooperation of the system. Assuming that the bird target image is represented as an d dimensional feature vector, the features of two given images are:

$$x=\left(x_1,x_2,\ldots,x_d\right)^T \quad (4)$$

$$y=\left(y_1,y_2,\ldots,y_d\right)^T \quad (5)$$

The cosine of the angle between them can be used as a similarity measure:

$$\mathrm{Sin}_t\left(x,y\right)=\frac{x\cdot y}{\|x\|\|y\|} \quad (6)$$

The distance between two histograms can be measured by histogram subtraction:

$$D_h\left(x,y\right)=\frac{\sum_i^d \min\left(x_i,y_i\right)}{\min\left(\sum_i^d x_i,\sum_i^d y_i\right)} \quad (7)$$

Before image processing, it is necessary to filter out the influence of illumination and background, otherwise, its influence on parameters will make the extracted gradient values change too much and distort the results.

If the image has a lot of noise and a relatively poor smoothness, the above two methods have certain limitations. At this time, the image can be preprocessed by pseudo-color processing and smooth denoising. There are various ways to collect images, and the original images often have certain noises or partial defects, which leads to the incomplete transmission and processing of image information. Especially the bird images, which are often acquired when birds fly, are affected by the factors of light, speed and distance, so it is difficult to directly process the images. It is

At the same time, the area that meets the above conditions is considered as the bird area that completely enters the horizon. Otherwise, the birds are not completely in sight. If one of the conditions is met, it means that the birds have completely entered the horizon horizontally or horizontally.

If we want to accurately get the correspondence between 2D observation and 3D attitude, we must acquire enough dense samples to learn decision rules and regression functions. Figure 2 is a schematic diagram of corrosion and expansion in Wushu bird tracking.

necessary to smooth the images by means of preprocessing and denoise the image information.

III. Result Analysis and Discussion

The laser beam emitted by the laser bird repeller is a secondary laser, which only stimulates birds temporarily and will not cause permanent damage to birds. The light beam can directly shoot people's skin, and it will not cause harm to the skin. However, during installation, it is not advisable for staff or people around it to directly look at the light beam, so as to avoid eye discomfort caused by strong light stimulation. Before image recognition, in order to reduce the calculation of image processing, the image should be segmented first. Image segmentation is mainly to separate the foreground object from the background, and the usual way is to binarize the image. It takes advantage of the difference in gray scale between the target and the background to be extracted in the image, regards the image as a combination of foreground and background in two areas with different gray scales, and selects an appropriate threshold to determine whether each pixel in the image belongs to the foreground or background area, so as to generate the corresponding binary image and get the target to be detected. The bird matching problem can be regarded as a classification problem, so that the tracking matching problem can be treated as a classification problem. The comparison of the average absolute errors of the algorithms is shown in Figure 3.

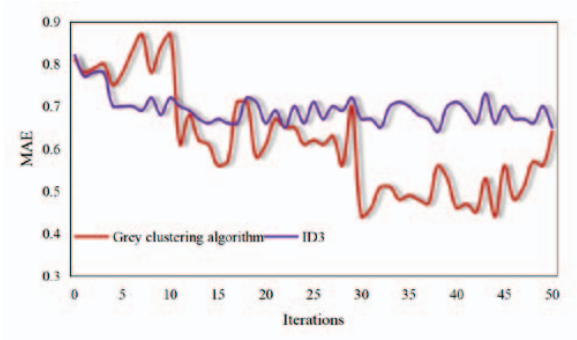

Figure 3. Comparison of MAE of algorithms

It can be seen that, compared with the method in literature [11], the grey clustering algorithm has obvious advantages in the later stage of operation, and the error is reduced by 38.64%.

When a bird enter that coverage area of the intelligent device, the intelligent device converts the bird image acquired in real time into a frame image, and judges whether the frame image match the existing training model; if so, it can be judged that the bird performs the next operation; otherwise, the intelligent device will continue to stand by. After it is determined that it is a bird, it starts to track the target, at the same time outputs the signal to release the ultrasonic frequency band, and transmits a series of acquired data to the background subsystem in real time. The accuracy of bird movement recognition is taken as the test index, and the method in literature [11] is selected as the contrast object. The experimental results are shown in Table 1 and Table 2.

Table 1. Accuracy of bird movement recognition based on grey clustering algorithm

Sample size	Accuracy of bird identification (%)
15	98.95
30	98.22
45	97.81
60	97.55
75	96.55
90	96.12
105	95.26

Table 2. Recognition accuracy of bird movement based on literature [11]

Sample size	Accuracy of bird identification (%)
15	96.74
30	95.55
45	95.12
60	94.07
75	93.85
90	93.26
105	93.01

Real-time data transmission function, the front-end equipment can not only store the backup target bird data by itself, but also transmit the collected data to the background subsystem through the network in real time. This can effectively ensure the background administrator to master the real-time data of bird activities. Compare the accuracy and recall of the algorithm for bird feature recognition, as shown in Figure 4 and Figure 5.

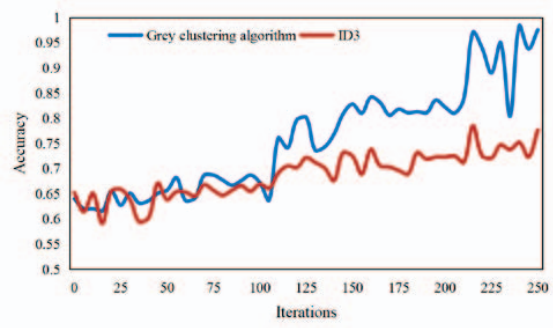

Figure 4. Comparison of accuracy of bird feature recognition

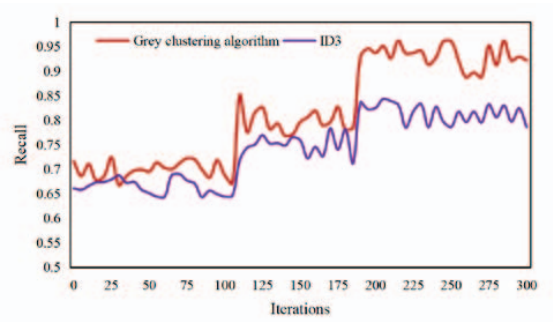

Figure 5. Comparison of recall rate of bird feature recognition

The detection results show that the accuracy of this algorithm is higher than that of the comparison algorithm, the accuracy is 25.72% higher, and the recall rate is increased by 17.37%, which can accurately locate the edge contour of the bird target. The frequency band released by bird repelling equipment is higher than the hearing range of human ears, and the ultrasonic waves in this frequency band have no effect on human beings and will not interfere with

their normal activities. Moreover, compared with the traditional audio-frequency bird repelling, ultrasonic wave breaks the restriction of geographical terrain, and its use effect will not be weakened because of different geographical terrain, so it is more suitable for wide-range popularization and use.

IV. Conclusions

The distribution line is close to the residential area, with wide coverage and complex environment, so it is an ideal place for birds to breed. Radar has certain advantages in detecting birds, especially when visual inspection is limited, such as at night, cloudy or snowy. Even in the daytime with good weather conditions, radar can detect long-distance targets that are difficult for human eyes to observe. The benefits of birds to nature and human beings are well known, but the frequent activities of birds have brought some harm to the safe operation of HV transmission lines. In this paper, an algorithm of bird target extraction based on grey clustering is proposed to detect the target birds in the transmission line scene, and the decision threshold is used to further increase the resilience of the background complexity, thus effectively improving the bird detection rate. This algorithm is more accurate in identifying the characteristics of birds, with a 25.72% higher accuracy and a 17.37% higher recall than the comparison algorithm, and it can accurately locate the edge contour of the birds. The research of automatic intelligent laser bird repelling device for power distribution line combines Doppler radar detection technology, electronic control pan/tilt technology, laser beam shaping and expanding technology and intelligent working mode, which can effectively and continuously repel birds.

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