Research on Application Technology of Wave Gate in Anti-jamming for Infrared Detection

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Abstract: The principle of wave gate was introduced. Wave gate is a kind of anti-jamming technique. When finding aim, system made a bit of section in a signal detecting cycle as wave gate, and disposed only signal in wave gate, so scope of signal disposed was reduced. Wave gate had been applied successfully to guided weapon. With development of infrared imaging technology, wave gate is developed. It can reduce greatly computation and enhance capability of anti-jamming for infrared imaging detection. The experiment proved that the method had good effect.

1. Introduction
At present, advanced countries in the world are competing to develop imaging detection technology, of which infrared imaging detection technology is most widely used. The imaging detection technology of our country is in the process of development. Infrared imaging detection has made very large change in infrared target detection and recognition. It achieves target detection by recognizing infrared images, so that the detection method has strong ability against background and artificial jamming. Wave gate is a certain time interval that is cut out for target signal processing in each detection cycle. It plays a vital role in the detection of infrared point targets. The method of infrared imaging detection turn relationship that the space, time and signal into relationship that the space and time. It’s important that wave gate is used in infrared imaging detection, and it will plays an important role in anti-jamming.

2. Wave gate application in anti-jamming for infrared point target detection
The infrared interference source is divided into non-artificial interference source and artificial interference source. The non-artificial interference source mainly includes the infrared radiation of the sun, the atmosphere, the cloud, the ground and objects on the ground etc. The artificial interference source mainly includes infrared jammer, directional infrared jamming system, infrared decoy, infrared smoke, infrared stealth, and so on[1]. The infrared images, such as non-artificial interference sources and infrared smog, are very different from artificial flying objects, so they can be easily identified. The development of infrared invisible technology is not perfect. Compared with the detection capability of the current high-performance infrared detectors, it is not enough to pose seriously to the infrared imaging detection system.

The infrared interfering projectile produces high temperature flame by chemical reaction, which produces strong infrared radiation in spectral range, and it deceives the detection system. Now deception technology has been developed from single method to infrared / radio composite method. Even after thrown, it can form target shape that achieves the purpose of interfering detection system. Infrared jammer is a kind of active infrared confrontation device, which can emit accurately infrared modulated
pulses, and it fabricate false signals with strong light, heating or fuel to deceive the detection system, so that the system loses the target. The directional infrared jamming system causes the infrared jamming energy to concentrate into the narrow beam. When the detection system approaches, the beam will make the detection system confused[2].

When the target appears, the detector obtains the target waveform information and establishes the relationship between the target information and the time. According to the target waveform occurring time in cycle, the target trajectory is calculated in order to determine its position in the next cycle. We select time interval and set wave gate, as shown in figure 1. The wave gate’s width can be adjusted according to the target signal width. Generally, target signal width is far less than the width of the whole cycle signal. Information only in wave gate will be processed in the next cycle.

![Figure 1 wave gate detection](image)

Through setting wave gate, we can enhance the anti-jamming ability. When the target and interference also appear in the detector, if there is a certain line of sight angle difference, the interference will be located outside the wave gate and will not be detected.

Wave gate width is related to target waveform width and maximum sight angle each cycle. In order to improve anti-jamming ability, we should as far as possible to reduce the width of wave gate. However, when the interference and target coincide, in order to detect target waveform when interference source and target will separate, we appropriate to relax wave gate width, and it made wave gate to accommodate separated target waveform.

The distance between target and detector is far. If artificial interference appears, interference source and target always coincide at beginning. Target energy should increase significantly in a short time, and detector will enter anti-jamming state in time. The waveform before energy increase is recorded as reference waveform that is used to distinguish target when interference source and target separate.

3. Wave gate application in anti-jamming for infrared area target detection

We do not need to establish the relationship between target information and time in infrared imaging detection. The infrared CCD is a solid self scanning camera. The camera is used to realize scene imaging by detector array. Each array element corresponds to the unit of the scene space, and the whole array corresponds to the whole area space observed[3]. As shown in Figure 2.

![Figure 2 Solid self scanning infrared imaging system](image)
In imaging detection system, the concept of wave gate changes. It is no longer appropriate peak within time period, but suitable region in imaging array.

3.1. To determine the size and location of wave gate

To infrared target in the air, the main background is atmosphere, cloud and ground. The target gray level is determined by temperature as the atmospheric environment and the infrared imaging system unchanged. The size of target is determined by size of target, the distance from target to imaging system and view field of the imaging system. When the target image on focal plane is small, that is a point target. When the target image on focal plane is big, that is an area target. The signal to noise ratio is low to point target, and the features are:

1) The target imaging area is very small on focal plane, only one or several pixels, without shape and structure information, and is similar to noise.

2) The target is not related to gray level of background. In general, the change of background is slow, and internal change is more uniform. There is strong correlation between pixels. Background information mainly occupy low-frequency part of image, Target and noise information mainly occupy high-frequency part of image.

When area target appears in the field of view, the infrared radiation is stronger, and the signal-to-noise ratio and available information of the image increases. It mainly including complexity, aspect ratio, mean contrast, compactness and so on.

To determine location of wave gate, we must first be coarse positioning of target. According to the characteristics of the above analysis, the point with maximum gray value was selected as center of wave gate in the image whose noise was already filtered. After distinguishing point or area target, if was point target, according to the preset pixel number to set size of wave gate, if was area target, according to complexity, compactness and so on to numerical judgment, the right wave gate was set. As shown in figure 3:

3.2. The algorithm on data address in wave gate

Each pixels in infrared focal plane corresponding to actual one physical space, the imaging data after preprocess stored sequentially in the storage area, then each storage unit would correspond to a physical space. As shown in Figure 4,
Therefore, the relationship between the target information and the storage address is easy to build. When target detected, wave gate is set up immediately. We only process storage unit data in wave gate, as can enhance system anti-jamming ability, and the signal processing cycle is shortened.

In Figure 3, it is wave gate that is surrounded from p to q in X axis and from I to h in Y axis. According to storage address and array matrix of infrared focal plane, we can calculate address of stored signals in wave gate of focal plane. In the figure, the focal plane is m * n, if base address of data storage unit is B, the first pixel of lower left corner coordinates is (0, 0), and each pixel occupies byte number is K. Then in accordance with the pixels from left to right, from bottom to top, the pixel’s coordinates is (c, d), and its address of storage unit is Ac.

$$A_c = B + k \left( (m-1) d + c \right)$$

So, pixel area’s addresses in wave gate that from p to q in X axis and from i to h in Y axis are Aw.

$$A_w = B + k \left( (m-1) v + u \right) \text{, among, } u \in [p, q - 1], v \in [i, h - 1]$$

The signal processor only needs to process signal in the Aw, and according to the target trajectory, setting next cycle of wave gate, if the cycle of signal processing is very short, we can also set one wave gate in many cycles.

4. experiment and analysis

Figure 5 (a) was an infrared image. There were two kinds of experiments. One was set wave gate and other was not set. We segmented image respectively with Otsu method. In the segmented image, the target with high gray value was kept. The background gray value was low, and it was changed to 0 after image segmented. Figure 5 (b) was the result of unused wave gate; Figure 5 (c) was the result of used wave gate and image segmented once; Figure 5 (d) was the result of used wave gate and image segmented twice. It could be seen that segmentation in wave gate is effective.
Not only the segmentation effect is better, but also the time complexity of the operation is small. The data in Table 1 was run time of each algorithm. It is tested with Matlab7.0 compiled environment on PC with 1.8 GHz AMD CPU.

Table 1 run time comparison

| figure5 (a) image size | figure5 (b) segmentation unused wave gate (s) | figure5 (c) segmentation in wave gate once (s) | figure5 (d) segmentation in wave gate twice (s) |
|------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|
| 136*272                | 0.3590                                      | 0.1880                                      | 0.2990                                      |

5. conclusions

The technology of infrared imaging detection is in high speed development period, and the infrared imaging anti-jamming technology still needs to be further improved. To set reasonable wave gate to narrow the range of information processing is a good way to improve the anti-jamming ability, and it will play an important role in the process of anti-infrared interference.

Acknowledgments

This research is supported by the fund of education department of Anhui provincial (No. KJ2018A0599), National Nature Science Foundation of China(No.51769027) and Anhui Sanlian university(PTZD2018009).

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