

Radar emitter intrapulse signal blind sorting under modified wavelet denoising

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Abstract: With the electromagnetic environment becoming more and more complex and the analysis demand of the radar emitter intrapulse signal presenting more and more urgent, a modified method of the radar emitter intrapulse signal blind sorting under wavelet denoising is proposed. This study aims to improve the weak adaptability to the noise of the fast independent component analysis (FastICA) algorithm and its blind source separating performance. In this method, a pre-processing of noise based on the modified wavelet denoising is added. Then the FastICA algorithm is used to sort the unknown radar emitter intrapulse signal for the next intrapulse signal analysis. Simulations and analysis indicate that the modified method improves the signal to noise ratio of the received intermediate signals and the blind sorting performance.

1 Introduction

In the radar reconnaissance and confrontation of modern electromagnetic warfare, the electromagnetic environment is more and more adverse and the signal becomes more and more complex [1]. Radar signal sorting is the front part of radar emitter recognition [2], location, and tracking, whose result directly influences the latter reconnaissance counter-measure system's performance. Hence, it is vital to complete the radar signal sorting precisely and rapidly in the complicated environment. Radar signal sorting aims to separate a single radar signal from the random mixed signal flows by the radar reconnaissance equipment in the high-density signal environment. Radar signal sorting [3] mainly depends on signal parameters, including interpulse and intrapulse parameters. At present, most of researches on the radar signal sorting are based on the interpulse parameters: carrier frequency, pulse width (PW), pulse repetition frequency, time of arrival (TOA), angle of arrival, pulse amplitude, etc. Also, signal sorting [4] is finished according to the correlation of the same radar's parameters. Radar signal sorting based on the intrapulse parameters mainly selects distinctive features to represent each signal, such as multi-dimensional statistical features, time-frequency features, and entropy, by which the signal component is extracted in sequence.

In the complex electromagnetic environment, radar signal blind separation is an effective method for radar emitter intrapulse signal sorting [5]. Huang first applied the technology of blind signal extraction to radar signal sorting and found feasible [6]; Li analysed the FastICA algorithm, used it in radar signal sorting, and achieved good separating performance; Xiong raised a new improved algorithm combining the Newton method with negentropy as an objective function to optimise the FastICA algorithm and eliminate the influence of the initial value. Also, all these researches are centring on how to improve the blind separating effect in the complex electromagnetic environment:

- Find the initial value to eliminate its influence on the algorithm's convergence;
- Improve the iterative algorithm to be independent of the initial value and has a faster convergence speed;
- Add pre-denoising to improve the algorithm's anti-noise performance.

Therefore, lots of work have been done on the former two problems, and attained good performance, but they did not considerate the algorithm's anti-noise performance. In this work, we establish the model of radar emitter intrapulse signal blind

sorting, modify the wavelet denoising algorithm to improve the signal quality, and use the FastICA algorithm to realise the intrapulse signal blind sorting. The modified wavelet denoising (MWD) achieves improving the blind separating performance based on FastICA. This paper is organised as follows. Section 2 describes the problem, makes the hypothesis, and establishes the research model. In Sections 3 and 4, the FastICA algorithm is analysed and two MWD algorithms are proposed. Simulations and discussions are displayed in Section 5 to indicate the improvement of our work. The conclusion is given in Section 6.

2 Problem description and hypothesis

After the signals are pre-processed by the radar reconnaissance receiver, the mixed signals are sorted according to different parameters to attain the single radar emitter signal. Also, those are usually applied into the mixed radar emitter intrapulse signal sorting. However, it is also important to sort the mixed radar emitter intrapulse signal, for example, the radar emitter intrapulse signal analysis, the recognition on intrapulse signal modulations [7], and specific emitter identification.

The blind sorting of mixed radar emitter intrapulse signals uses distributed receivers to collect different mixed signals which are separated by the blind source separation algorithm. Finally, we get the single radar emitter intrapulse signals; the whole process is shown in Fig. 1. N radar emitter signals in complicated electromagnetic environment are described as

$$S(t) = s_1(t), s_2(t), \dots, s_N(t), \quad (1)$$

and after they are mixed and then received by M distributed receiving equipment, it becomes

$$X(t) = x_1(t), x_2(t), \dots, x_M(t), \quad (2)$$

in which the $x_i(t)$ ($i = 1, 2, \dots, M$) is the mixed unknown radar emitter intrapulse signal. Under the MWD, the FastICA algorithm based on negentropy separates the mixed signals and gets the estimation of source signals

$$Y(t) = y_1(t), y_2(t), \dots, y_N(t). \quad (3)$$

In the process of sorting on mixed radar emitter intrapulse signals, radar general parameters are ignored. Also, the signal sorting problem is transformed into the blind source separation problem.

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