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An Improved multiple fractal algorithm

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Abstract. Multiple fractal dimensions can depict the geometry characteristic of the signals from different levels, thus it can extract the features of different signals. The paper proposed an improved algorithm of multiple fractal dimension, it changed the calculation method of traditional multiple fractal dimension which accumulated the q dimensions characteristics. It increased the regularity and gathered degrees of the signals' characteristics, under the condition that the basic computational complexity of algorithm was not changed. Simulation results show that, for the classification of different signals, the improved algorithm has better property.

Keywords: Multiple Fractal Dimensions; Geometry Characteristic; Signal Feature

1 Introduction

Radar echoes usually contains a lot of information related to the target feature and a variety of stray echoes, therefore, t has been a hot topic that how to extract the characteristics of radar intra-pulse signal in the low SNR environments which in order to identify the radar signals. For the feature of the radar intra-pulse signals' characteristics, the theory of signal complexity characteristics, entropy theory and fractal theory get the more extensive application. References [1] used the signals' complexity feature box dimension and index entropy double complexity characteristics to identify the communication signals achieved a better result. References[2] improved the traditional box dimension, although it increases a certain amount of calculation, the recognition effect have been significantly improved. References[3-4] applied the multifractal spectrum characteristics to the identification of the radar signals' intra-pulse modulation characteristics. References [5] provided the method calculating discrete signals' multifractal spectrum characteristics and annotated the meaning of multiple fractal dimension spectrum.

From the point of view of the measure, fractal dimension [6] which usually used to represent the degree of irregularity fractal sets expanded the dimension from integer to fraction and broke through the boundary that general topological dimension is integer. Thus It has been a wide range of application in various fields. The paper improved multiple fractal dimension characteristics after comparing with the traditional multiple fractal dimension characteristics. The simulation results showed that compared with the traditional algorithm, it decreased amount of calculation and

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far more stable than traditional multiple fractal dimension algorithm and had better application value.

2 Multiracial theory

2.1 Traditional multi-fractal dimension algorithm

Multiple fractal dimensions can describe the features of the objects in various ways. The method to define the traditional multiple fractal dimension is as follows:

The research object divided into N micro-regions, suppose the length of the "i" region is $\sum_i$, then the probability density function of this region P_i can be describe by the scaling exponent $\langle_i$:

$$= \sum_r , \ i \ 1,2,\cdots = ,N_i(1) \text{ Non-integer } \langle_i$$

was generally called singularity exponent, its value was related to the region. Defined the function $X_q\ (\sum)$ which was the probability summation of all regions: $X_q(\sum) = \sum_{i=1}^{N} P_i^q$ weighted

From this, the further definition of the generalized fractal dimension " D_q "was:

$$D_q = \lim_{\sum \to 0} \frac{\ln\left(\sum_{i=1}^{N} P_i^q\right)}{q-1 \ln \sum}$$

$$= 1 \lim \ln X_q(\sum) = \frac{1}{q-1} \lim_{\sum \to 0} \frac{\ln\left(\sum_{i=1}^{N} P_i^q\right)}{q-1 \ln \sum}$$

Different q showed different property of probability characteristic area, by means of weighted summation processing, we divided a signals into numerous regions with different singular degree. Thus we could know the refined structure of internal signals step by step.

2.2 Improved multi-fractal dimension algorithm

The paper improved the multi-fractal dimension algorithm. In the evaluation process of D_q, we cancel the summation of probability in different regions and calculate the multifractal characteristics of signals which in different levels directly.

Defined the function $X'_q(\sum)$: $X'_q(\sum) = P_i^q$ .And the improved multiple fractal dimension D'_q is :

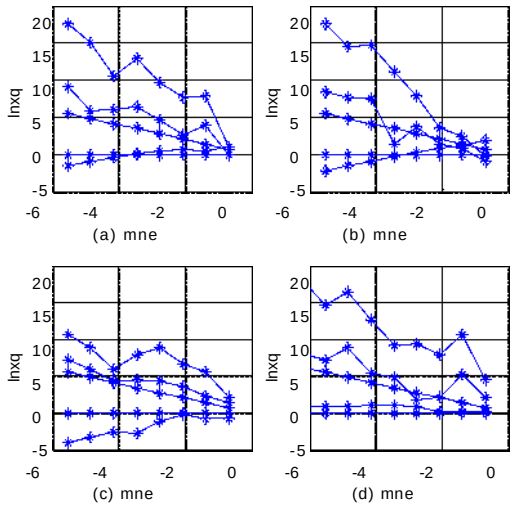
$$D'_q(\sum) = \lim_{\sum \to 0} \frac{1}{1-q} \frac{\ln \sum_{i=1}^{N} P_i^q}{\ln \sum} = \lim_{\sum \to 0} \frac{\ln \sum_{i=1}^{N} P_i^q}{(1-q)\ln \sum}$$

D_q is the value of improved multiple fractal dimension at present.

D_q and D_q both could describe the signals characteristics in different levels, the result of D_q showed the signals' distribution characteristics in each level. It reduced an addition summation and had a better feature extraction effect.

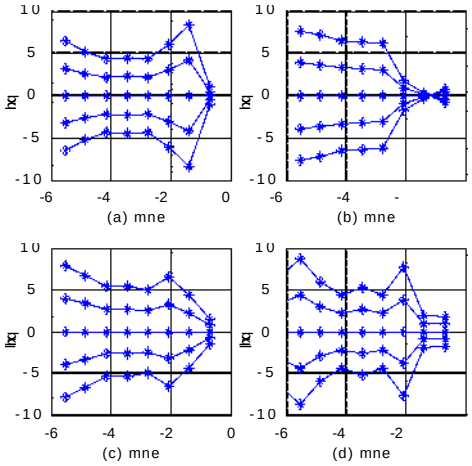
3 Simulation results and analysis

On the basis of the multiple fractal dimension, in the SNR for 10dB conditions, we got the numerical value of four different kinds of radar signals: chirp signal, stepped frequency signal, frequency shift keying signal and phase shift keying signal, and drew multiple fractal dimension. Figure 1 and figure 2 showed the simulation results.



(a) Chirp signal (b) Stepped frequency signal (c) Frequency shift signal (d) Phase shift signal

Fig. 1. Four kinds of radar signal' traditional multiple fractal dimensions



(a) Chirp signal (b) Stepped frequency signal (c) Frequency shift signal (d) Phase shift signal

Fig. 2. Four kinds of radar signal' improved multiple fractal dimensions

Abscissa $\ln e$ represent $\ln\varepsilon$ in the formula (2), ordinate $\ln xq$ represent $\ln X_q(\varepsilon)$ in the Formula $X_q(\varepsilon) = \sum_{i=1}^{N} p_i^q$

4 Conclusion

The paper proposed an improved algorithm of multiple fractal dimensions. The algorithm cancels the summation of characteristic parameter in different levels compared with the traditional one. In the premise of simplified algorithm, the radar signal's multiple fractal dimensions we extract had better stability and lay a better foundation for the rest of the classifier recognition work.

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References

1. Avci, D., Nsiala Nzéza, C., Berbineau, M., etal. An intelligent system using adaptive wavelet entropy for automatic analog modulation identification[C]. GLOBECOM - IEEE Global Telecommunications Conference (2010)
2. Ataollah Ebrahimzadeh. Automatic Modulation Recognition Using RBFNN and Efficient Features in Fading Channels [C]. 2009 1st International Conference on Networked Digital Technologies (2009)
3. Hua Jing-yu, Meng Li-min, Xu Zhi-jiang, etal. An adaptive signal-to-noise ratio estimator in mobile communication channels[J]. vol. 20(3), pp:692-698. Digital Signal Processing(2010)
4. Mahmoudi, Alimorad, Karimi, Mahmood. Parameter estimation of noisy autoregressive signals[C]. 2010 18th Iranian Conference on Electrical Engineering(2010)
5. Shermeh Ataollah Ebrahimzadeh, Ghazalian, Reza. Recognition of communication signal types using genetic algorithm and support vector machines based on the higher order statistics[J].vol. 20(6), pp: 1748-1757. Digital Signal Processing (2010)

