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Research Article

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Direction of arrival estimation for fewer snapshots signal in the impulsive noise environment

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ABSTRACT

The bootstrap is a great technique for assessing the accuracy of parameters estimator, that have been widely applied on statistical and signal processing problems. A novel algorithm based on block bootstrap for DOA estimation in small size of snapshots is proposed in impulsive noise background. We filtered the received array signals to reduced the impact of the impulsive firstly. Then resampled the data for 1000 times to create a new matrix, therefore an arrival angle is estimated by the root-music algorithm in the conditions of confidence interval. Simulation results show that higher estimation probability and smaller mean square error can be achieved in the situation of fewer snapshots received by passive radar system than that of traditional algorithm.

Key words: DOA; block bootstrap; residual method; root-music

INTRODUCTION

The problem of DOA estimation of radar signal is important part in array signal processing, it has been a hot spot in many areas [1]. The general techniques for the DOA estimation of array signal processing include the conventional beamforming method（CBF）and the high-resolution direction finding method[2].Because CBF has been gradually replaced by the High-resolution algorithm due to the Rayleigh limit. In 1979, Schmidt proposed the MUSIC [3] method which promotes the development of subspace algorithm for array signal processing. It created a precedent of subspace algorithms.Most subspace algorithm has infinite resolution according to the assumptions of asymptote conditions (if we have infinite number of snapshots or SNR) [8], so called " super-resolution " algorithm. In order to improve the performance estimation, researcher tend to only be interested in finding or improve algorithm in the past of the array direction finding technology research, ignoring the array structure. In practical applications, it is difficult to continuous capture of many radiating source pulses, so the number of snapshots and SNR are often unsatisfactory. Therefore the DOA estimation method in fewer snapshots has important practical significance. In recent year, the correntropy based correlation (CRCO-MUSIC)[5]、the extended pth-order cyclic MUSIC algorithm (EX-POC-MUSIC) [6]、 the reconstructed fractional lower order covariance(RFLOC-MUSIC)[7] and other algorithms in Ref[8] are proposed to solve the problem of direction under different conditions .All above methods need large number of snapshots,but it is difficult to capture the enough snapshots in the complex electromagnetic environment.So we proposed a novel method to solve the problem.

The bootstrap technique was introduced in 1979 by Bradley Efron [9]. Although the theory of bootstrap is simple but it has subsequently been used to solve many problems in signal processing field that would be too complicated for traditional statistical analysis. After decades of development, the frontier research includes the independent and identically distributed data (i.i.d), Model-based, the block (or moving block) bootstrap, the naive bootstrap, Sieve bootstrap etc. Applications of Bootstrap have been reported in radar signal processing [10], Image processing [11][12], and time-frequency analysis [13]. In all these fields, bootstrap methods have been used to approximate the distribution of an estimator. Different to most methods of computing parameter estimators for the true parameters, which assume that the numbers of sample are very large, the few samples in bootstrap are resampled by computer. These assignments and re-computations are done hundreds of times and treated as repeated experiments. In essence, this method can be used for few real data to get good parameter estimation as large real data. The bootstrap becomes an extremely attractive tool in that it requires very little in the way of modeling, assumptions, or analysis and it can be applied in an automatic way. The bootstrap is essentially a computer-based method that substitutes considerable amounts of computation in place of theoretical analysis [14]. In the field of array signal processing, Brcich [8] used bootstrap methods for multiple hypothesis testing, and proposed a novel number of sources estimation method based on narrow band array model. Zhihua[15] applied the bootstrap to the number of sources estimation under impulse noise, ect. However, there are few reports on the DOA estimation, so the research of DOA using bootstrap is actively significance.

Signal model
The setting for the data model is as follows: N narrow band sources with same wavelength impinging on an Uniform Linear Array (ULA) with M sensors and the spacing between the adjacent elements is half wavelength. The array received data is given by:

$$X(t) = AS(t) + N(t) \tag{1}$$

The covariance of received data is given by:

$$R_x = \mathrm{E}[x(t)x(t)^H] = AR_sA^H + R_n \tag{2}$$

The proposed method
According to the characteristics of impulsive noise, we filtering and limiting the received signal firstly. Then resampling the data using the block-bootstrap and rebuilding the matrix.The general process is shown in Tab1.

Table 1: The steps of proposed method

Step1:Preprocessing the signal data received from ULA.
Step2:Calculate the covariance(R_x) of the processed data.
Step3:Resample the R_x to get R_X^* using the bootstrap method
Step4:Estimate the sample eigenvalues, calculate the direction of arrival with root-music.
Step5:Repeat the step 3 to 4 B times to obtain the set of angle.
Step6:Recalculate angle according to the confidence interval use the empirical distribution.

The particular steps of step1 are as follows:
Get the absolute values of the vector data received from the ULA, and find out the maximum ($X_{i\max}$)and mean($\bar{X}_i$) from the absolute values;

If $X_{i\max} \geq a * \bar{X}$,then $X_{i\max} = b * \bar{X}$,or remain the $X_{i\max}$.

Repeat these steps until all the values are less than $a * \bar{X}$.

Define $a = \dfrac{20(1+\alpha)}{0.5+\sqrt{GSNR}}$, and $b = 0.6(2+\alpha)$, where $\alpha \in (0,2]$ is the characteristic coefficient of the impulsive noise and the $GNSR$ is Generalized SNR.

Simulations
Experiments are conducted in this section to compare the effectiveness of the proposed strategy and the other methods (FLOM,RFLOC).

Experiment 1: Assuming the $\alpha = 1.6$ and the $GSNR = 5$,the number of snapshots $\mathrm{L} = 1000$, the filtering results is shown in Figure 1:

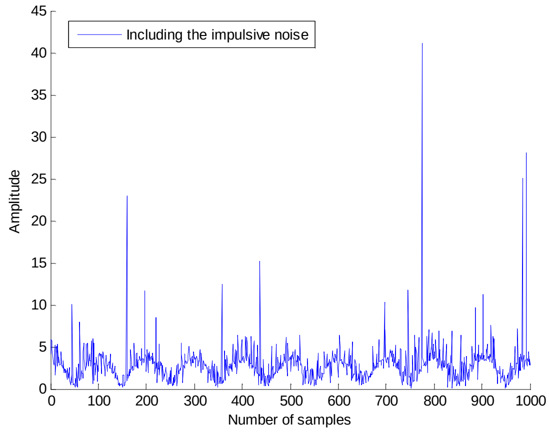

Fig 1a: The data including the impulsive noise

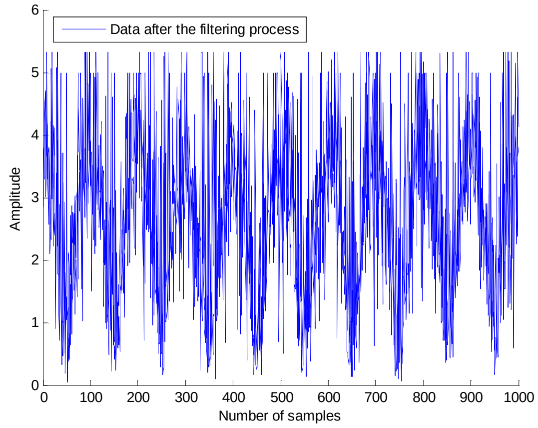

Fig 1b: The results after filtering

Experiment 2: Assuming that one narrow sources impinging on ULA with 4 sensors. The distance of adjacent sensors is half of the wave length of signals received. The azimuth angle of signal is 30°, the $GSNR = 5$,and the $\alpha = 1.2$. The signal was resampled 1000 times. Each group of experiments is carried for 200 times though Monte Carlo simulation to compare the three algorithms under the conditions of varied snapshots. If it is assumed to be successful with the estimate θ^* is confined $|\theta^* - \theta| \leq 0.5$,then the probability of successful of the three algorithms have shown in Fig.2 .

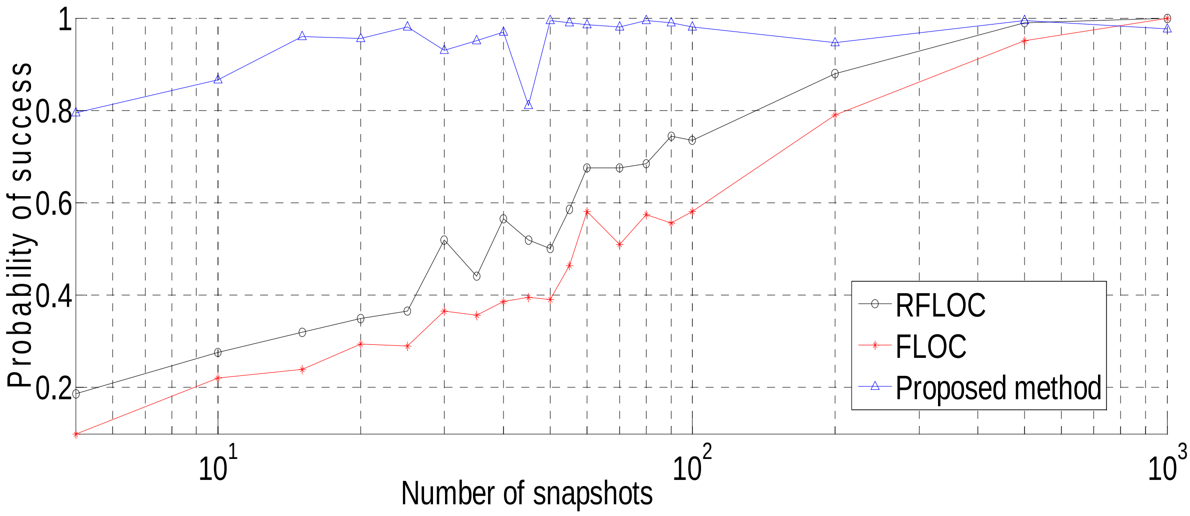

Fig 2: The probability of success in varied snapshots

In the Fig.1a we can see that the received signals which including the impulsive noise, and the curve in the fig1.b are limited effectively. The proposed method is compared with the other two algorithms in fig.2.The probability of successful is superior to the others in the condition of $L < 250$.

CONCLUSION

A novel algorithm based on filter and bootstrap for DOA estimation of fewer snapshots in impulsive noise environment is proposed. The first step is to filter the received array signals and second step is to create a new matrix by using the bootstrap method, then an arrival angle is estimated by the music algorithm in the conditions of confidence interval . It is illustrated that the proposed method has higher probability of successful estimation compared with the FLOC algorithm and the RFLOC algorithm which runs Monte Carlo simulation for 200 times in the conditions of fewer snapshots. The fewer the number of snapshots the more obvious effects in the fig.2, however the parameter curve of proposed method have not stable and linear because of the inherent disadvantages of bootstrap. We plan to improve the confidence interval and using the new model to approximate of the true value to increase probability of success in the future research.

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REFERENCES

[1] Ben-Ari, Erez, and Jacob Remez. *Antennas and Wireless Propagation Letters, IEEE* 10 (**2011**): 1076-1080.
[2] Capon, Jack. "High-resolution frequency-wave number spectrum analysis." *Proceedings of the IEEE* 57.8 (**1969**): 1408-1418.
[3] Schmidt, Ralph O. *Antennas and Propagation*, IEEE Transactions on 34.3 (**1986**): 276-280.
[4] Brcich, Ramon F., Abdelhak M. Zoubir, and Per Pelin. *Signal Processing, IEEE Transactions* on 50.2 (**2002**): 206-215.
[5] Qiu Tianshuang, Zhu Yong, Zhao Saiyuan, Zha Daifeng. "The Properties of FLOC and its application in evoked potential latency change detection.[C]" IEEE International Conference on Innovative Computing Information and Control, Dalian, **2008**: 355.
[6] Zhang, Jinfeng, et al. *Signal Processing*, **2014**: 346-357.
[7] You, Guo-hong, Tian-shuang Qiu, and Ai-min Song. *Circuits, Systems, and Signal Processing* ,**2013**,32(6) : 2939-2956.
[8] Gao Hongyuan ,Diao Ming. *Chinese journal of radio science*,**2009**,24(4):729-734.
[9] Efron, Bradley. *The annals of Statistics* (**1979**): 1-26.
[10] Foucher, Samuel, Grégory Farage, and Goze B. Bénié. "Application of bootstrap techniques for the estimation of Target Decomposition parameters in RADAR polarimetry." Geoscience and Remote Sensing Symposium, **2007**. IGARSS 2007. IEEE International. IEEE, **2007**
[11] lKybic, *Image Processing, IEEE TransactionsVol*. 19, Issue: 1, Jan. **2010**, pp. 64 – 73
[12] Chuang, S. C., and W. L. Hung. "Image classification using bootstrap likelihood ratio method." Machine Learning and Cybernetics (ICMLC), 2010 International Conference on. Vol. 2. IEEE, **2010**.
[13] Politis, Dimitris N. *Statistical Science* 18.2 (**2003**): 219-230.
[14] A.M.Zoubir, *Signal Processing Magazine*, IEEEVol:24,July **2007**, Page(s): 10-19
[15] Lu, Zhihua, Yacine Chakhchoukh, and Abdelhak M. Zoubir. "Source number estimation in impulsive noise environments using bootstrap techniques and robust statistics." Acoustics, Speech and Signal Processing (ICASSP), **2011** IEEE International Conference on. IEEE, **2011**.