Journal of Theoretical and Applied Information Technology
10th March 2013. Vol. 49 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

THE RESEARCH OF NOVEL SPATIAL SPECTRUM ESTIMATION ALGORITHM BASED ON THE MULTI-SCALE SYSTEMS

[1]JING ZHANG, [2]KECHENG LIU, [3]CAIXIA YANG

[1]Lecturer, College of Computer and Information Engineering, Nanyang Institute of Technology, Henan Nanyang 473004, China

[2]Prof., College of Computer and Information Engineering, Nanyang Institute of Technology, Henan Nanyang 473004, China

[3]Asstt Prof., College of Computer and Information Engineering, Nanyang Institute of Technology, Henan Nanyang 473004, China

E-mail: [1]eduzhangjing@163.com

ABSTRACT

Spatial spectrum estimation of is an important branch of array signal processing. A multi-scale system theory is the key to the multi-scale system to define a new concept, which is similar to the discrete time system Z transform. This paper mainly introduces the spatial spectrum estimation of beam forming method, linear prediction method, subspace method, parameter method, and for each algorithm were discussed analysis comparison. The paper presents the research of novel spatial spectrum estimation algorithm based on the multi-scale systems. Experiment results show that this system is feasible and efficient. Finally, by using the Gram method and the rank criterion method for multi-scale modeling of controllability are shown.

Keywords: *Spatial Spectrum Estimation, Multi-scale, Wavelet Transform*

1. INTRODUCTION

People know that there are many physical phenomena are in different time scales to produce. However, how too systematically information will be added to the appropriate process model, or how to use the information to solve some basic problems in process industry has become a problem to be solved, for example, control, estimation, diagnosis. The traditional model, only provides a in different scale physical convolution expression method. But, in the different processes used in industry process model consists of different time scales.

Spatial spectrum estimation is a spatial processing technology, because of its superior spatial parameters (such as the azimuth angle estimation performance), and attracted a vast number of scholars to study, and it is widely applied to other field [1]. Spatial spectrum estimation of array signal processing is an important branch, so its basic theory is inseparable from the array signal processing of the basic principles, namely through the space of the data received by the array of phase difference to determine one or several parameter to be estimated, such as the azimuth angle, elevation angle and the number of signal sources.

Beam forming is in a given direction is formed on the main beam for receiving the useful signal, in the other direction to form zero to suppress the interference signal. Its essence is a multichannel array signal processing system, which is different from the usual time domain signal processing, also different from the frequency domain processing, is a spatial filter concept.

With the wavelet transform and multi rate of development, the multiresolution signal processing research more and more attention from the academic circles. The multiresolution signal processing research is mainly based on signal multistage representation, two binary tree model and stochastic process for multi-scale modeling and multi-scale signal processing provides a useful framework. In order to establish multi scale model and the multi-scale model forward effective multi-scale processing algorithm requires the development of a multi-scale system theory and the multi-scale model theory.

Journal of Theoretical and Applied Information Technology
10th March 2013. Vol. 49 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Linear prediction (LP) algorithm is a time series analysis of commonly used a method, which uses a series of known static discrete stochastic process sampling data, predicting the future or past data. Predicting the future data is often referred to as the forward prediction and the prediction of past data is often referred to as to the prediction. A multi-scale system theory is the key to the multi-scale system to define a new concept, which is similar to the discrete time system Z transform. As a result of multi scale model and multi-scale signal processing algorithms are established in two fork tree, so our main task is to define the basic two fork tree " dynamic mobile " operator. As a result of quadrature mirror filters (QMF) group is a multi-scale signal representation of the tower foundation.

Scale domain can provide a fast and parallel algorithm. The classic model representation method is not able to use the frequency domain controller design method, because of the presence of a hardware constraint. Multi scale domain framework in time and scale domain moment, it provides a similar time domain frequency domain environment to indicate the specific requirements. In the classical model predictive control is the most important issue in the domain length, scale domain which can pass through different methods to solve. The multi-scale model predictive control algorithm is to meet the requirements of the feasibility and optimality. State estimation method of multi-scale representation, can also fit into the multi-scale error statistics, and can also fit into the more object related information and rich feedback error. The paper presents the research of novel spatial spectrum estimation algorithm based on the multi-scale systems.

2. MULTI-SCALE SYSTEM THEORY

On a family tree, it has the concept of distance, that is to say if it is the tree of two nodes, then the distance between them, which is in the shortest path between nodes and the number of branches. For a given tree we first give the demarcation point. Prior to this, we first give the tree partial sort, so they can give a rule, this rule can be pointed out that this node. When, the corresponding tree representation for the set of integers, it has two boundary points [2]. The fact that the integer increments to decline to two sequences are equal, that is to say, and it is their difference is that a finite number of nodes.

This recursive transformation can also be converted to a matrix operation. In this conversion of residual value of information in different scale is different, and the reference point is similar to the signal's rough approximation. Therefore, the signal can also be passed beneath the coefficient to express, as is shown by equation1.

$$p(s(k)) = \frac{1}{\left(2\pi\sigma^2_{s(k)}\right)^{1/2}} \exp\left[-\frac{\left(s(k)-S_0(k)\right)^2}{2\sigma^2_{s(k)}}\right] \quad (1)$$

The multi-resolution representation method is described as a tree of dynamic system, the said method provides a signal and the phenomenon of multiple resolutions modeling of a hypothesis, which in turn directly produce a optimal resolution of the signal and image processing are useful methods. Willsky et al and use these observations to detect scale recursive model, which produced a Schur-Levison method and a Kalman filter for multi scale routine. On the important signal transformation and image processing problems, with the likelihood computation of correlation algorithm, thus produced some new methods; they include multi-scale data fusion, in a sequence of images behavior estimation and texture identification.

Will describe a transformation-based linear system framework, it is from the time domain to the frequency domain numerical and feature conversion. These characteristics of the converter as well as its general, makes the multi-scale linear system theory is very valuable. The existing theory of linear systems in many systems theory characteristics, can be in without making any changes to the case of conversion to multiple scale domain, so that we can not do any modification can be used in both time domain and frequency domain method.

In the state space or input / output model of the dynamic process of the state, input and the measured variables, the continuous models are defined in the set of real numbers, if it is a discrete time model is defined on the set of integers. State, input and measurement in time domain of wavelet transform allows us to define these variables, they can pass a tree to describe. However, the results produced by the model characteristic is not obvious, in the promotion of industrial changes and improve engineering application is also not particularly attractive characteristics [3]. The engineering application refers to the simulation, estimation, linear process control, on the dynamic behavior of the optimization. In this section we attempt to clarify these issues. Consider the input output model -- by the integral of the product under test is given, as is shown by equation 2.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

$$\sigma_{\Omega}^{2}=\frac{1}{A_{\Omega}}\iint_{(x,y)\in\Omega}[(I(x,y)-\bar{I}_{\Omega}]^{2}\,\mathrm{d}x\mathrm{d}y$$

(2)

These expressions do not change the order of the model. In the time domain n order model, if along through the scale or in a given time direction, then in any given scale will also maintain order n. Of course, an arbitrary high order model can be converted to a first-order model [4].

A multi-scale model is designed to be the problem in time domain conversion to multiple scale domains to consider, so you can make full use of time domain and frequency domain properties, thereby reducing system noise and improve the robustness of the system.

Discrete linear time invariant multi-scale systems are controllable, if given an initial state node, i.e. a scale starting point. So this system can be a limited set of input makes it possible to obtain any node state. Here and in the distance is limited, i.e., and it is the scale and the control input, as is shown by figure1.

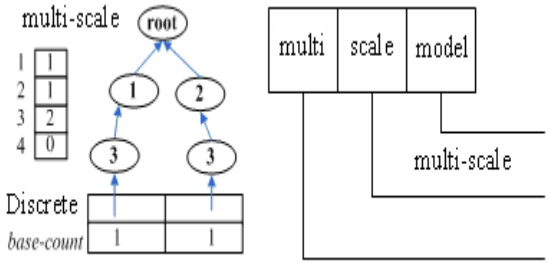

Figure1. *Multiple scale domains to consider figure*

That is not state observed, contradiction and known system completely observation. The set is not established, nonsingular. Necessity may permit. Certification is in order to completion. Although the character of Rahm matrix observability criterion is simple in form, but as a result of the multi-scale system state transfer matrix solution on difficulties, makes the specific application of discriminant is restricted, so can view character Rahm matrix distinguishing significance mainly lies in the theoretical analysis.

The results show that, we need to get on the scales of the process model, measurement and control behavior. However, the classical Fourier analysis method is only provided by said method. He in an infinite time range gives the process and the measurement frequency behavior of information [5]. At the same time is in a limited time blocking their handling characteristics. So we need a framework, it can provide dynamic process, measurement and control behavior representation, and in the frequency and time (scale).

Wavelet is a meet certain requirements of function, the integral is zero, it is in the X axis of wave. They are localized and they ensure that the wavelet transform in direct and reversible on calculation is fast and easy. There are many kinds of wavelet: smooth compactly supported wavelet, wavelet, with simple expressions for the wavelet and simple correlation filter. Similar in Fourier analysis of sines and cosines, wavelet as indicated being other function basis function. Although wavelet was localized in the frequency and time, but it's not like Fourier transform. On the control theory is an important advantage is localized.

Application of wavelet transform in another important advantage is that: the computational complexity. Fast Fourier transform has complexity, however fast wavelet transform only. Now consider a continuous signal which is in the space (all square integral function), and produced the following approximate sequence.

We can use the scale function to filter correlation signal, the signal than we wanted the approximation, the scaling function is presented as a low-pass filter. Extended parameters, said sampling a continuous function of time scales [6].

Wavelet and scale function are based on a recursive method to define. Equation (3) in a continuous scale clearly reflected in the scaling function and wavelet function between the recursive relations. This recursion is not only the basis function the relationship between is the relationship between coefficients. Said that such a relationship is the best way to tree representation, and it is also described.

$$\begin{cases}\Psi^{1}(x,y)=\varphi(x)\psi(y)\\ \Psi^{2}(x,y)=\psi(x)\varphi(y)\\ \Psi^{3}(x,y)=\psi(x)\psi(y)\end{cases}\qquad(3)$$

As long as it meets the above requirements, so in the following discussion content can be applied to any kind of wavelet function. In the absence of special conditions, for simplicity and effectiveness, we will be Hear wavelet as the example. Chart depicted in one of two binary tree recursive relations [7]. Assuming that there is a time

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

sequence, the sequence in the two forks tree at the same sampling interval is projected onto the scales.

Bassevile et al first recognized in it in the importance of family tree. (a): it is pointed out that the wavelet coefficient of the signal, (b) directly in the tree is defined on the process generates a system theory. Note is made of a tree provides the signal representation framework to map to be flexible. For example, it can be applied to a higher dimensional tree (to the signal he is defined in a multi-dimensional space, for example, time, and space coordinate), the tree may be asymmetry can also be a general outline [8]. This flexibility can and signal components in the special multi-scale structure matching. The multi-scale process model to estimate and control research, family tree and its translation will play a very important role, in the next section we will summarize the main definitions, as well as in the subsequent sections using these characteristics.

In the discrete Fourier transform, the translation operation and, they are a translation operation on. Translational value sequence is far away from the. However, the discrete Fourier transform of the corresponding tree is an order; it is a single operation, if it is in a two fork tree, from each one of the nodes it with a two subset of nodes. We need two from boundary point to shift the operation. The obvious upward is the translation operation and the corresponding.

Multi-scale system theory framework, which is defined in the two forks tree translation, from a certain sense it represents the transformation in frequency domain [9]. These frameworks, it comes with some similar to the realization, causality and the transfer function of the system theory characteristics. It can provide a good environment, used to describe the image, signal stability and even some simple dynamical system, but it can not be ignored in process control used in the dynamic system of standardization. The existing framework of superiority manifested in a concise and the optimal approach to the static information, but it is in the modeling, simulation and control is not conducive to the operation, as is shown by equation 4.

$$\varepsilon_i = \sum_{X \in \Omega_i} [I_t(X) - I_k(W(X,P))]^2 \quad (4)$$

If these internal state and input is correct, then this recurrence relation is effective, state in many times it is through the equation (4) to mean. But the input requirement is a difference in average. As mentioned earlier, the wavelet can not simulation compound leaf unfolding and convolution way. So in this scale undertook a certain number of convolution operations. In view of high order dynamic model would be written as the following situation.

Fu Liye transform of the basic idea is to decompose a signal into a series of different frequency continuous sine wave, or from another point of view is that the signal from the time domain to the frequency domain conversion, but the Fu Liye transform is a serious deficiency, that is to transform in lost time information, not based on Fu Liye transform results judge whether a specific signal when it happened. That is to say, the Fu Liye transform is a pure frequency domain analysis method in frequency domain, it is positioned exactly (i.e., frequency resolution, while the highest) in the time domain without any resolution.

Analysis of the position signal and frequency are characteristic. The use of wavelet analysis of non stable transmission signal analysis, we can get the signal in time domain information, but also can get the information in the frequency domain, this can be a very good signal determined location and frequency characteristics.

3. SPATIAL SPECTRUM ESTIMATION ALGORITHM THEORY

Wave direction of arrival (DOA) estimation in radar, sonar, mainly are in the field of research and development. As the airport control tower is used to observe the position of the aircraft radar. We also install a television antenna, the antenna toward the correct image source direction; it is a direction of arrival DOA estimation [10]. An antenna using a estimation of direction of arrival (DOA) is easier to achieve. But the angular resolution is dependent on the directivity of the antenna, in addition, also need antenna mechanical scanning. If you use the spatial configuration of the array antenna, not rotating antenna, also can realize to the direction of arrival (DOA) estimation.

By selecting the suitable adaptive algorithm, it can implement real-time on antenna pattern mulling. So it can deal with a plurality of active jamming, the received useful signal, so that the output of system signal to noise (including various interference) is larger than the maximum, in order to improve the detection performance of radar system. Choice of weighted adaptive algorithm is very important, because it not only determines the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

convergence speed and the complexity of the hardware required for a decision.

The most general adaptive algorithm is the least mean square (LMS) algorithm, LMS is based on the steepest descent method, and this method can be recursive computation and update the weight vector. The rationality lies in the gradient vector in the negative direction of the weight vector continuous amendment ultimately resulting MSE, then get the optimal weight vector [11]. According to the method of steepest descent, in time to update the weight vector can be represented by the following simple recursive relations to seek.

An accelerated convergence method is to use the inverse covariance matrix. If the desired and interfering signal is known, can estimate the covariance matrix, and calculate the weight vector. In fact, the signal is unknown; the signal environment is also changing with frequency. Therefore, the adaptive processor must be continuously updated to meet the new needs of weight vector. In the absence of a priori information, update the weight vector is required in the finite observation interval was obtained and estimates, and use these estimates to obtain the desired weight vector, as is shown by figure2.

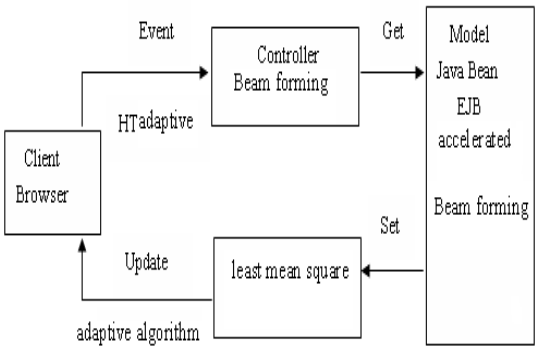

Figure2. Beam Forming Method And Linear Prediction Figure

Array element identified one dimensional signal vector space, of which an interference signal vector is constituted of a dimensional interference signal subspace. In order to reconstruct the interference signal vector subspace, in radar pulse deluge interference signal vector is sampled, the obtained channel noise in the sampled signal. In the first snapshot the sampled signal vector.

Based on the weight calculation method, adaptive algorithm can be divided into closed loop and open loop algorithm gradient algorithm. At present, the open-loop algorithm has been paid more and more attention, its main reason is the algorithm converges fast, and requires only limited input data can accurately describe the characteristics of external environment [12]. The convergence of adaptive algorithm for SMI and G-S orthogonal resolution algorithm, and it is thus becoming the preferred algorithm.

Linear prediction is based on the known time sequence to estimate the future or past time series method; it is with the help of the prediction filter and prediction error filter to achieve. Prediction filter function is a predictor of the time required sequence value; prediction error filter function is based on the actual and predicted values to adjust the errors between prediction filter weights.

An array by weighted summation, an array can be received direction gain focus in one direction, equivalent to form a beam [13]. Figure 2 is adaptive beam forming principle diagram. Adaptive signal processor's role is, according to the spatial array of input signal and output signal adaptive form weight vector, different weight vector can be formed in the beam pointing in different directions, and the desired signal maximum output power direction is the direction of incident signal.

$$PV(x)=\frac{1}{y_2-y_1}\sum_{y=y_1}^{y_2} I(x,y)\,, \quad x\in(x_1,x_2)$$

(5)

Because the MEM algorithm successfully breaks through the Rayleigh limit, thus further to attract the majority of scholars on this issue in-depth and extensive research, such as the double linear prediction algorithm. These LP algorithm research for feature subspace algorithm for the rise of foundation, but also promote the LP algorithm research. LP type algorithms have a common drawback is the spectrum peak search will appear when the artifact peaks, but through some method to suppress.

Having high direction accuracy and it is high resolution and to multiple signals at the same time direction and the instantaneous short signal direction finding. Thereafter, based on the characteristics of decomposition of the super resolution spatial spectrum estimation technology has received extensive attention and study, proposed many algorithms, such as minimum convolution (MN), MUSIC root method, the rotational invariance technique parameter estimation method ESPRIT, as well as for direction finding of coherent signal source spatial smoothing method. In the ideal case, they have relatively less

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

computation, but also has the traditional methods can not match the direction of super resolution.

$$K_E(x)=\begin{cases}\frac{1}{2}c_d^{-1}(d+2)(1-\|x\|^2), & if\ \|x\|<1\\ 0, & if\ \|x\|\geq 1\end{cases} \quad (6)$$

The MUSIC algorithm is used to receive data covariance matrix to isolate the signal subspace and noise subspace, using the signal direction vector and the noise subspace orthogonally to form the spatial scanning spectrum, the realization of the signal parameter estimation.

ESPRIT algorithm to estimate the signal parameters of array geometry requires the existence of so-called invariant, this invariance can be obtained through two kinds of methods : one is the array itself has two or two above the same subarray; two is through certain transform to obtain two or two above the same sub array. With the in-depth study of the ESPRIT algorithm, ESPRIT algorithm is further by the majority of scholars accept and promotion.

Known ESPRIT algorithm basic principle is the use of type (2-71) rotation invariance, conventional rotational invariance subspace algorithm is to use the basic principle for solving the signal incident angle information [14]. The analytical solution of the equation of the two kind of commonly used methods: least squares (LS) method and total least square (TLS) method.

Rotation invariant subspace (ESPRIT) algorithm is the spatial spectrum estimation algorithm in a typical MUSIC algorithm, it also needs the array covariance matrix eigen decomposition. But two have the obvious difference, namely MUSIC algorithm is the use of the covariance matrix of the noise subspace orthogonal property, and ESPRIT algorithm is the use of the data covariance matrix signal subspace rotation invariant properties, so the ESPRIT algorithm and MUSIC algorithm can be viewed as a complementary relationship. Compared with MUSIC algorithm, ESPRIT algorithm has the advantages of small amount of calculation, does not need spectrum peak search.

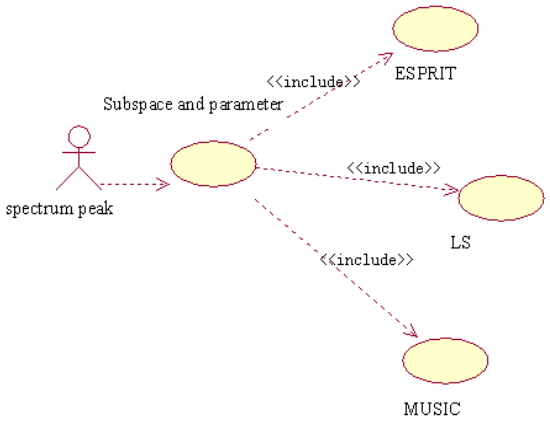

Figure3. Subspace Method And Parameter Method Figure

The Bias method is based on the statistical theory of a classical method, suitable for the parameter estimation problem. Maximum likelihood (ML) estimation method is Bias method for estimation of a special case of white noise, are known in the case of Bias optimal estimation. In the algorithm ML, observed signal of the likelihood function is defined as containing the unknown parameters of the conditional probability density function, purpose unknown parameters is selected to make the likelihood function is as large as possible. By maximizing the likelihood function of the obtained solution are considered to be an estimate of the unknown parameters.

In the estimation of spatial spectrum, according to the incident signal model, maximum likelihood algorithm is basically divided into two classes: deterministic maximum likelihood (DML) and stochastic maximum likelihood (SML) [15]. When the incident signal obeys the Gauss random distribution model is derived for the maximum likelihood algorithm is the SML algorithm, and when the signal model is unknown when determining model derived from the maximum likelihood algorithm called DML algorithm.

Hypothesis of mathematical model of the additive noise is white noise, assuming that the steering vector of array manifold matrix of linear independence, snapshots requirements ensure the statistical properties of the effectiveness. The following discussion is based on the hypothesis of the maximum likelihood criterion, as is shown by equation 7.

Journal of Theoretical and Applied Information Technology
10th March 2013. Vol. 49 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

$$\left.\begin{aligned} Z_1 &= H_1 X + V_1 \\ Z_2 &= H_2 X + V_2 \\ &\cdots\cdots \\ Z_r &= H_r X + V_r \end{aligned}\right\} \quad (7)$$

Subspace fitting algorithm consists of two parts, namely, the signal subspace fitting and noise subspace fitting. Signal subspace fitting, signal subspace into space with the array manifold is a space with a space, that is to say the signal subspace spatial array manifold into a linear space, only when the estimated signal and real signal number equal to the number.

4. SPATIAL SPECTRUM ESTIMATION ALGORITHM BASED ON THE MULTI-SCALE SYSTEMS

Closed loop control, adaptive control, error diagnosis, control strategy, process, operation plan, including the dynamic process model. At present, in the research of modeling, the group in different scale expansion of interconnected project, how to produce an actual model does not have a definite method. This also implies that the business decision process of restraining. Enterprise resource planning, manufacturing execution system and process control system is the main part of the procedure, and these links contained in different time scales. In theory, every link will be consistent with the remaining part, but in reality, every link using a different model, so it is difficult to obtain the consistency.

The maximum likelihood method and subspace fitting algorithm is a nonlinear multidimensional optimization problem, and both have many similarities: maximum likelihood algorithm is equivalent to the data (receiving data and actual data) between the fitting, and the weighted subspace fitting is a Yu Zi space (receive data subspace and the actual signal steering vector composition subspace) between the fitting; both of them need to pass multidimensional search algorithm to solve, so many used to achieve ML algorithm procedure can be applied directly to the weighted subspace fitting algorithm, as is shown by equation8 [16].

$$\sigma\left\|(V(k,t))\right\| = \sqrt{\frac{1}{n}\sum_{i=0}^{n-1}\left(\left\|\overline{V(k,t)}\right\| - \left\|V_i(k,t)\right\|\right)^2} \quad (8)$$

In order to make the spectral estimation to break through the Rayleigh limit constraint, increasing the angle resolution, spatial spectrum analysis is also used some similar spectrum estimation in nonlinear processing, resulting in some algorithms such as multiple signal classification method (MUSIC), rotational invariance techniques parameter estimation (ESPRIT), minimum convolution (MN), projection matrix and matrix decomposition. These methods are cleverly using the received signal of the covariance matrix of the feature structure. Here, especially the MUSIC algorithm, the estimation precision is high, is the most classic of the algorithm.

Experiment: assume two coherent signals, respectively from and incident to the 57 array element on a uniform linear array, signal to noise ratio are 200dB, snapshot number is 879, the array element spacing and the wavelength ratio. As shown in Figure 4 is the classic MUSIC algorithm and backward smoothing algorithm for coherent signal estimation and spatial smoothing sub array number is 23. Experiment 2: the assumption of two coherent signals, respectively from and incident to the 300 array element on a uniform linear array, signal to noise ratio are 206bB, snapshot number is 454.

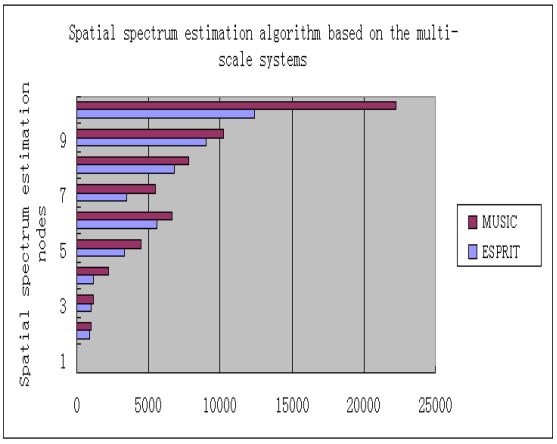

Figure4. Compare Of Spatial Spectrum Estimation Algorithm Based On The Multi-Scale Systems Music With Esprit

The paper presents the research of novel spatial spectrum estimation algorithm based on the multi-scale systems. Compared with parameters, usually spectral function method is more less advantages, but may not be able to give accurate estimates, especially due to multi-path and related strong signal. Make full use of the data and the parameters of the model method in the estimation of the correlation signal has its unique advantages, but due to the multiple search, so the computation load is increased. Briefly introduced the multi-scale system

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

theory knowledge, then according to linear system establishment of multi scale model finally, and it is by using the Gram method and the rank criterion method for multi-scale modeling of controllability and Operability for proof.

5. CONCLUSIONS

This paper mainly introduces the spatial spectrum estimation of beam forming method, linear prediction method, subspace method, parameter method, and each of the algorithms are discussed for comparison, behind the power iteration algorithm and multiple signal classification algorithms for uniform linear array and circular array laid the foundation. The paper presents the research of novel spatial spectrum estimation algorithm based on the multi-scale systems. A multi-scale system theory is the key to the multi-scale system to define a new concept, which is similar to the discrete time system Z transform. As a result of multi scale model and multi-scale signal processing algorithms are established in two fork tree, so our main task is to define the basic two fork tree " dynamic mobile " operator.

REFRENCES:

[1] Peichang Shi, Huaimin Wang, Gang Yin, Fengshun Lu, Tianzuo Wang, "Prediction-based Federated Management of Multi-scale Resources in Cloud", *AISS*, Vol. 4, No. 6, 2012, pp. 324 ~ 334.

[2] Bi Juntao, "Research on the Image Fusion Method Based on the Improved Feature Segmentation", *JCIT*, Vol. 7, No. 18, 2012, pp. 339 ~ 346.

[3] Mi Liping, "Research on the Image Fusion Algorithm based on the Improved Multi-source Infrared", *JCIT*, Vol. 7, No. 16, 2012, pp. 322 ~ 330.

[4] Wencheng Wang, Faliang Chang, Tao Ji, , Guoqiang Zhang, "Fusion of Multi-focus Images Based on the 2-Generation Curvelet Transform", *JDCTA*, Vol. 5, No. 1, 2011, pp. 32 ~ 42.

[5] YAHIA S. AL-HALABI, HESHAM JONDI ABD, "NEW WAVELET-BASED TECHNIQUES FOR EDGE DETECTION", *Journal of Theoretical and Applied Information Technology*, Vol. 23, No. 1 ,2010,pp.125-132

[6] Li Xian-Guo, Miao Chang-Yun, Wang Wen, Zhang Yan, "Research on Fault Detection Algorithm of Steel Cord Conveyor Belt Based on Gabor Filtering and Image Fusion", *JCIT*, Vol. 6, No. 11, 2011, pp. 68 ~ 75.

[7] FU Qiang, LI Yi-bing, LIU Yue, "Improving Image Quality In Poor Visibility With Retinex-Based Adaptive Image Eenhancement Method", *JDCTA*, Vol. 5, No. 10, pp. 296 ~ 301, 2011.

[8] Ren Ya-fei, Ke Xi-zheng, "Selection of Wavelet Decomposition Level in Multi-Scale Sensor Data Fusion of MEMS Gyroscope", *JDCTA*, Vol. 4, No. 8, 2010, pp. 209 ~ 215.

[9] LI Jin-jiang, AN Zhi-Yong, FAN Hui, LI Ye-wei, "Multifocus Image Fusion Algorithms using Dyadic non-subsampled Contourlet Transform", *JDCTA*, Vol. 4, No. 6, 2010, pp. 36 ~ 47.

[10]T. Su，K. Dandekar，H. Ling, "Simulation of Mutual Coupling Effect in Circular Arrays for Dirction Finding Applications", *Microwave and Optical Technology Letters*，2000，26(5)：331-336.

[11] SOFIEN GANNOUNI, HASSAN MATHKOUR, MUTAZ BERAKA, "A COMPARATIVE SURVEY OF DATASHARING APPROACHES AND THEIR APPLICATIONS IN DISTRIBUTED COMPUTING ENVIRONMENTS", *Journal of Theoretical and Applied Information Technology*, Vol. 33, No. 1 ,2011,pp. 42-57

[12] P.E.Hyberg, "Circular to Linear Array Mapping Using Calibration Data", *IEE HF Radio Systems and Techniques, Conferece Publication ,Defence Research Establishment FOA*, Sweden. 2000:71-75

[13]Nan Dong, Fuqiang Liu, Zhipeng Li, "Crowd Density Estimation Using Sparse Texture Features", *JCIT*, Vol. 5, No. 6, 2010, pp. 125 ~ 137.

[14] SACHIN UPADHYAY , YASPAL SINGH, "CRYPTANALYSIS OF RSA THROUGH FORMAL VERIFICATION TOOLS", *Journal of Theoretical and Applied Information Technology*, Vol. 39,No. 1, 2012, pp 017 - 021

[15]Hai Guo, Jing-ying Zhao, Ming-jun Da, Xiao-niu Li , "NaXi Pictographs Edge Detection Using Lifting Wavelet Transform", *JCIT*, Vol. 5, No. 5, 2010, pp. 203 ~ 210

[16] AHMED ZEGGARI, FELLA HACHOUF, "USING GLOBAL FEATURES ON REFINED IMAGE PARTS FOR LOGO RECOGNITION", *Journal of Theoretical and Applied Information Technology*, Vol. 43, No. 1, 2012, pp 030 - 038