DOA Estimation Using Music Algorithm

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To Cite this Article

E. Vijaya Lakshmi, P.Nanda Kishore, T.Harshit, V.Sai Dinesh, P.Chiru Vardhan. DOA Estimation Using Music Algorithm. International Journal for Modern Trends in Science and Technology 2023, 9(05), pp. 867-873. https://doi.org/10.46501/IJMTST0905148

Article Info

ABSTRACT

Array signal processing is an important branch in the field of signal processing. In recent years, it has developed dramatically. It can be applied such fields as radio detection and ranging, communication, sonar, earthquake, exploration, astronomy and biomedicine. The field of direction of array signal processing can be classified into self-adaption array signal processing and spatial spectrum, in which spatial spectrum estimation theory and technology is still in the ascendant status, and become a main aspect in the course of array signal processing. Spatial spectrum estimation is focused on investigating the system of spatial multiple sensor arrays, with the main purpose of estimating the signal's spatial parameters and the location of the signal source. DOA estimation has a wide application prospect in radar, sonar, communication, seismology measurement and biomedicine. Over the past few years, all kinds of algorithms which can be used in DOA estimation have made great achievements, the most classic algorithm among which is Multiple Signal Classification (MUSIC).

KEYWORDS: Direction Of Arrival, Multiple Signal Classification, Spatial Spectrum

1. INTRODUCTION

Array signal processing has wide applications, such as radar, sonar, medicine, earthquake, satellite, and communication system. It becomes a hotspot and difficult point in the signal processing domain. Array signal processing aims at processing signals received by array antenna, strengthening useful signals, restraining the interference and noise, while at the same time collecting useful signal parameters. Compared with traditional signal orientation sensor, sensor array can control the beam flexibly, with a high signal gain and strong ability for interference. That is the reason why array signal processing theory can boom in recent decade.There are two research directions for DOA estimation, self-adaption array signal processing and spatial spectrum estimation. Self-adaption occurs earlier in literature than spatial spectrum and has already been used in many practical engineering systems. On the other hand, though spatial spectrum estimation has developed rapidly and had abundant references, it is rarely found in practical systems. At present, it is still being developed.

Spatial spectrum is an important concept in array signal processing theory. It presents thedistribution of signals in every direction in the space. Hence, if one can get the signal's spatial spectrum, one can get the direction of arrival (DOA). Consequently, spatial spectrum estimation can be also called as DOA estimation.

DOA estimation is a key research area in array signal processing and many engineering applications, such as wireless communications, radar, radio astronomy, sonar, navigation, tracking of various objects, earthquake, medicine and other emergency assistance devices that need to be supported by direction of arrival estimation [2]. In modern society, DOA estimation is normally researched as a part in the field of array processing, so many works highlight radio direction finding. Over the past ten years, Wireless Local Area Networks (WLANs) have increased quickly because of its flexibility and convenience. In order to satisfy the requirements of advanced services, a high-speed data rate is necessary.

The system is built such that billing information is sent to a central server in real-time using the ESP8266 Wi-Fi module which tracks all the shopping trolleys and allows the client to log into the integrated app to track purchase and make payments digitally on the spot. The ease of functionality, versatility, and adaptability of the RFID enabled shopping cart makes it a state-of-the-art system for shopping. On completion of the customer's shopping, he/she will press the button present on the trolley, which will lock it through the help of a servo motor installed on the trolley to provide security and prevent theft and the final bill will be generated.

2. LITERATURE SURVEY

In As A survey of beamformers together with adaptational beamformers is given in [1]. The conditions below that the adaptational beamformer performance degrades are seen in several papers. There exist variety of techniques to estimate the DOA of signals of interest. Here, a survey on ordinarily used techniques moreover as algorithms is created. In general, the DOA estimation adaptational beamforming algorithms could also be classified into Beamscan Algorithms, and Beamspace algorithms .

Diagonal Loading - Among the various sturdy adaptational beamformers projected within the literature, diagonal loading emerges because the most generally used methodology owing to its simplicity and its effectiveness in handling a good sort of errors, together with steering vector and finite-sample errors [4]. It's sturdy against finite sample errors [5]. However, a significant downside of the diagonal loading technique is that there's no reliable way to choose the diagonal loading issue, that directly affects its performance..

In A robust beamformer for the foremost general case of associate discretional dimension of the required signal topological space is developed in [11], and is applicable to each the rank-one and better rank desired signal models. The projected sturdy adaptational beamformers area unit supported express modeling of uncertainties within the desired signal array response and information variance matrix moreover as worst-case performance improvement. Closed type solutions and computationally economical on- line implementations of the sturdy rule are developed in [11].

Capon Beamforming - In [12], the sturdy Capon beamformer is projected, wherever the variance fitting formulation of the quality capon beamformer, is in addition to the constraint that the beamformer response be higher than some level for all the steering vectors that lie associate ellipsoid (sphere) centered on the nominal or plausible steering vector of interest.

3. METHODOLOGY

THE DOA ESTIMATION

DOA estimation stands for Direction of Arrival estimation, which is a signal processing technique used to determine the direction from which a signal or wave is coming. This technique is widely used in various applications such as radar, sonar, and wireless communication.

There are various methods for DOA estimation, including:

Beamforming: Beamforming is a signal processing technique used to estimate the direction of arrival of a signal by forming a beam towards the desired direction.
(Multiple Signal Classification): The MUSIC algorithm is a popular method for DOA estimation that uses eigenvalue decomposition of the signal's covariance matrix toestimate the directions of the incoming signals.
ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques): ESPRIT is another popular method that uses a rotational invariance property of a uniformlinear array to estimate the DOA of the incoming
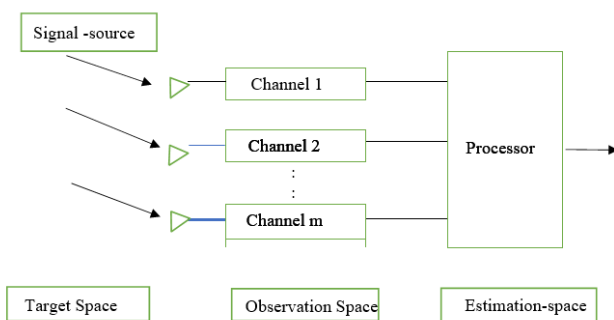
signals.

➢ **Maximum Likelihood Estimation**: This method is based on the principle of maximum likelihood and involves finding the direction of arrival that maximizes the likelihood of the observed data.

The choice of the DOA estimation method depends on the specific application, the signal characteristics, and the performance requirements.

The Spatial spectrum estimation is a specialized signal estimation technology that usesspacearrays to achieve a space signal parameter. The entire spatial spectrum system should becomposed of three parts: the incident signal space, spatial array receiver and parameter estimation. The space can be divided into three corresponding spaces, namely target stage, observation stage, and estimation stage.

The system structure of DOA estimation

Target stage is a stage that consists of signal source parameters and a complex environment. For the spatial spectrum estimation system, it uses some particular methods to estimate the unknown parameters of signals which come from this complex target stage.

Observation stage is a stage which receives the radiation signals from the target stage. Due to the complexity of the environment, the received data may contain some signal characteristics (azimuth, distance, polarization, etc.) and the space environment characteristics (noise, miscellaneous waves, interference, etc.). In addition, due to the influence of spatial array elements, the data received also contain some features of space array element (mutual coupling, channel inconsistent, frequency band inconsistency, etc.). This observation stage is a multidimensional stage which means that the system receivingdates are composed of plurality of channels, and

the traditional time domain processing method is usually only used for one channel. Of particularly note is that the channel does not correspond to the array elements; a spatial channel is formed by several or all of the synthetic array elements. There is no doubt that certain array elements in the stage may be contained within different channels.

MUSIC ALGORITHM : The Multiple Signal Classification (MUSIC) algorithm was proposed by Schmidt and his colleagues in 1979 [32]. It has created a new era for spatial spectrum estimation algorithms. The promotion of the structure algorithm characterized rise and development, and it has become a crucial algorithm for theoretical system of spatial spectrum. Before this algorithm was presented, some relevant algorithms directly processed data received from array covariance matrices. The basic idea of MUSIC algorithm is to conduct characteristic decomposition for the covariance matrix of any array output data, resulting in a signal subspace orthogonal with a noise subspace corresponding to the signal components. Then these two orthogonal subspaces are used to constitute a spectrum function, be got though by spectral peak search and detect DOA signals.

It is because MUSIC algorithm has a high resolution, accuracy and stability under certainconditions that it attracts a large number of scholars to conduct in-depth research and analyses. In general, it has the following advantages when it is used to estimate a signal'sDOA.

The ability to simultaneously measure multiple signals

➢ High precision measurement.

➢ High resolution for antenna beam signal

➢ Applicable to short data circumstances.

➢ It can achieve real-time processing after using high-speed processing technology.

4. SIMULATION

MATLAB is released by the U.S. MathWorks Company. It mainly faces scientific computing, visualization and interactive program designed for a high-tech computing environment. It makes numerical analysis, matrix computation, scientific data visualization, modelling and

simulation of nonlinear dynamic systems. Besides, many other powerful features are integrated in a windows environment which can be used easily. It provides a comprehensive solution for scientific research, engineering design, and an effective numerical solution for numerous scientific fields. It is out of the traditional non-interactive programming languages (such as C, FORTRAN) in some distance. It represents the highest level of the current international scientific computing software.

MATLAB is a kind of language, and is also a programming environment. MATLAB provides a lot of user-friendly tools to manage variables, input and output data, and generate and manage M files.

Users can type a command in the MATLAB command window. It can also write applications in the editor using the language it defines. After explaining the language, process them in a MATLAB environment, and finally returns the results. MATLAB language is simple, compact, easy to use, flexible, and has extremely rich library functions. The form to write a MATLAB program is free. Using functions from the library can avoid complicated subroutines programming tasks and compress all unnecessary programming work. Because library functions are written by experts in this field, users need not to worry about the reliability of function. It can say that using MATLAB technology is like standing on the shoulders of experts.
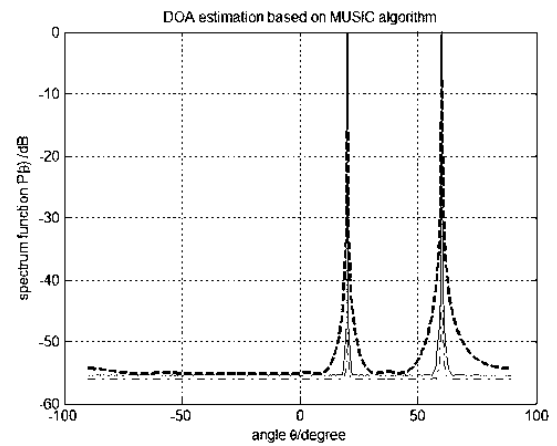
Since MATLAB is written in C language, it has the same operators like Clanguage. Using MATLAB operators flexibly can make the program extremely brief and easy to understand.
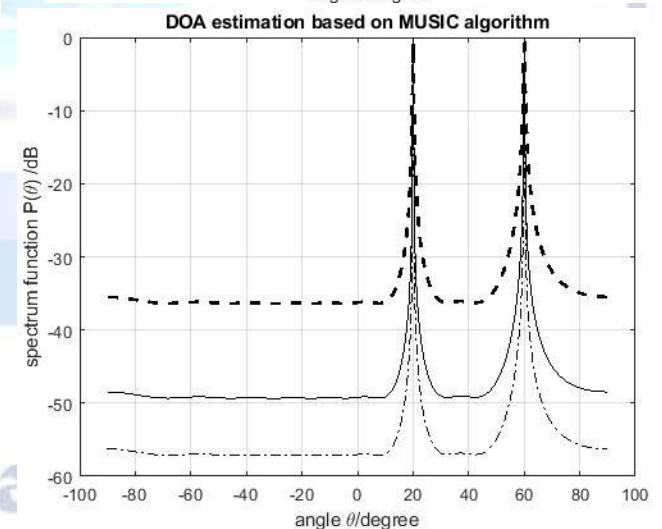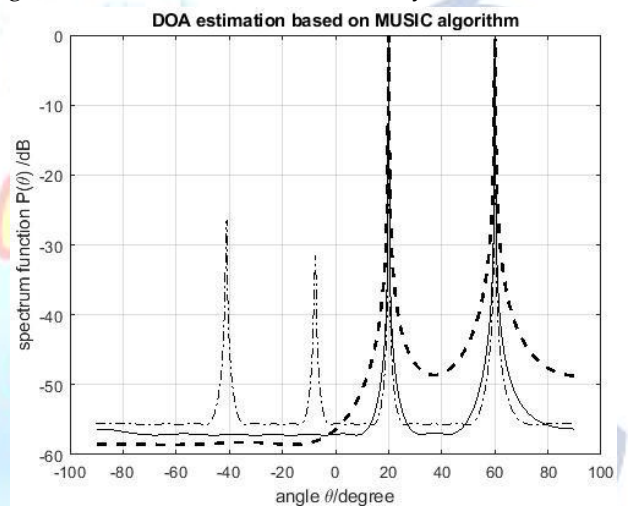
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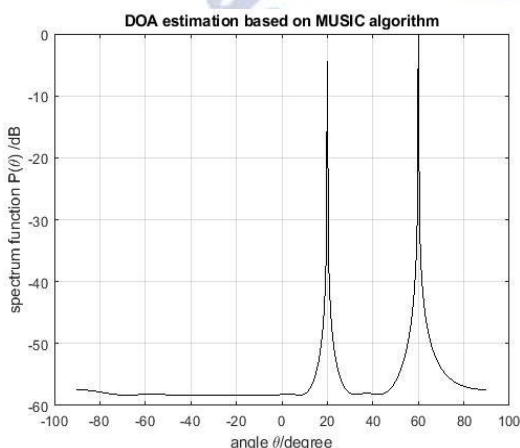
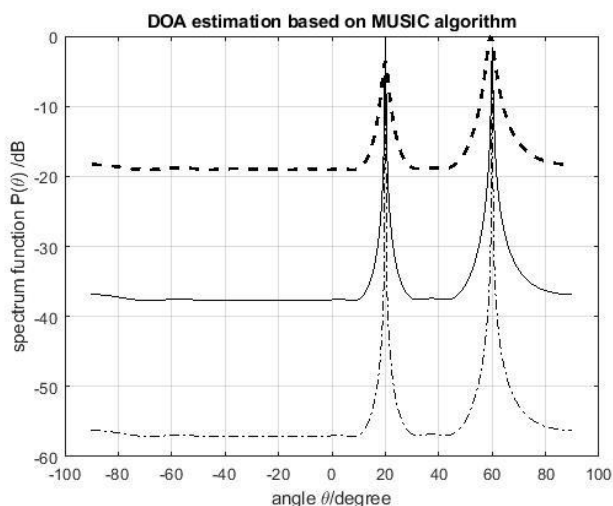Basic DOA estimation using MUSIC Algorithm Web

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Simulation For The Relationship Between Music Algorithm And TheNumber Of Array Elements

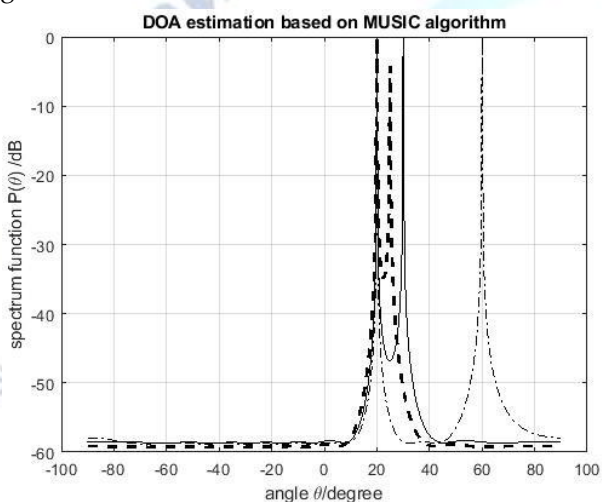
Simulation For The Relationship Between Music Algorithm And Array Element Spacing

Simulation For Relationship Between Music Algorithm And The NumberOf Snapshots

DOA estimation based on MUSIC algorithm

Simulation For The Relationship Between MUSIC Algorithm And SNR

DOA estimation based on MUSIC algorithm

Simulation For The Relationship Between MUSIC Algorithm And The Incident Angle Difference

DOA estimation based on MUSIC algorithm
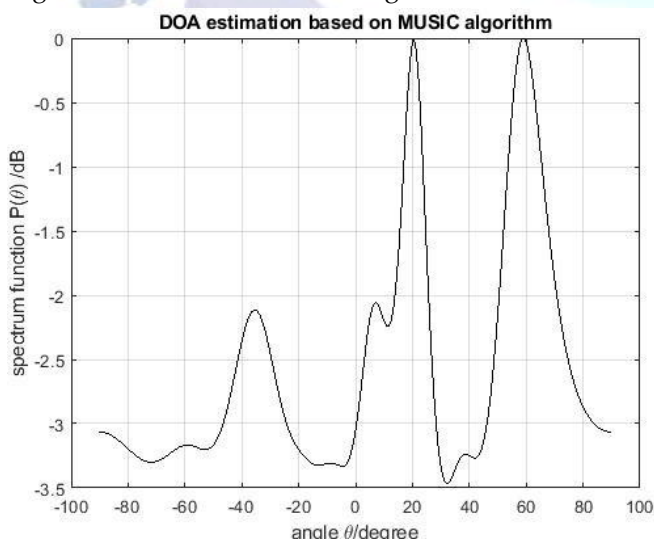
Simulation for MUSIC algorithm when the signals are coherent

DOA estimation based on MUSIC algorithm
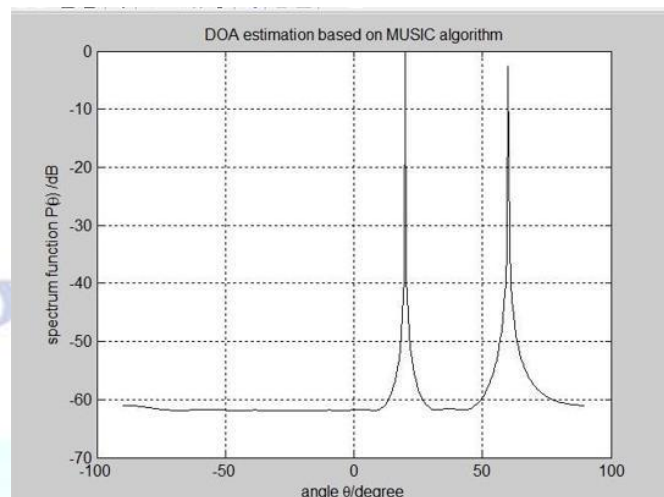
Simulation for the improved MUSIC algorithm when the signals arecoherent

6. CONCLUSION

DOA estimation plays an important role in array signal processing, and has a wide range of applications. In many areas, such as communication, radar, sonar, weather forecasting,ocean and geological exploration, seismic survey and biomedicine, DOA estimation problems may occur.

The key to DOA estimation is to use an antenna signal array which is located in differentspatial regions to receive signals from signal sources in different directions. Then the useof modern signal processing methods may quickly and accurately estimate the direction of the signal sources. In recent years, a variety of DOA estimation algorithms has achieved fruitful results, which provides a solid theoretical foundation for practical application. In this thesis, I have done some research for multiple signal classification theoretical study and simulation. The main contents and conclusions made in this thesis are summarized as follows:

In this thesis, by describing DOA estimation, spatial spectrum estimation, and giving a mathematical model of DOA estimation, an understanding of DOA estimation was provided. And then the MUSIC algorithm (Multiply Signal Classification) was implemented in MATLAB, and simulations were performed. From the simulations, it could be seen that the MUSIC algorithm has a higher resolution the more the number of array elements, the more the number of

snapshots, and the larger the difference between the incident angles. When the array element spacing is less than half the wavelength, the MUSIC algorithm resolution increases in accord with the increase of array element spacing, however, when the array element spacing is greater than the half of wavelength, except the direction of signal source, other directions appeared as false peaks in the spatial spectrum. When the signal is coherent, classical MUSIC algorithm has lost effectiveness, and improved MUSIC algorithm is able to effectively distinguish their DOA. I implemented the improved MUSIC algorithm for coherent signals. Finally, I puzzled out some problems by using the MUSIC algorithm in practical application and giving some solutions on those problems, then looked forward to the future of DOA estimation.

7. FUTURE SCOPE

DOA estimation theory and technology have become more mature, but there are many directions which need further research.

1) DOA Estimation Theory

Signal model areas. From a rational mathematical model to the study of more complex and more realistic environment signal model, this would lay a solid foundation for the application of spatial spectrum theory and algorithm. For example, consideration of the array signal model causes all kinds of error in the system, the features of noise in an actual environment, noise and signal correlation and distributed signal models.

New theories and new methods for DOA estimation. On the one hand, focus on the research of super-resolution DOA estimation theory and algorithm under general background is still necessary; on the other hand, focus on the research of DOA algorithm under specific background does not just stay in the research of general algorithm.

Information utilization aspect. Spatial spectrum estimation techniques not only use the information signal to estimate the spatial orientation parameters of the signal, but also make full use of the information of the time-domain signal. The different statistical characteristics of signal and noise as well as other available information is to increase the signal separability

to improve the DOS estimation performance. At present, this aspect of study concentrates on the use of information, for instance, the use of Doppler information signals to achieve a multidimensional parameter estimation dimensionality reduction; utilizing pulse echo signal to improve the signal to noise ratio; using high-order Cumulant to restrain Gaussian noise; using different signals Cyclostationarity to separate signals. Meanwhile, the time-domain information for DOA algorithm is not deep enough, for example, the use of Doppler information dimensionality reduction will have much impact on DOA estimation; utilizing pulse information will bring much extent to estimates the signal subspace and noise subspace; the requirement of high-order cumulants to the number of samples and all of this requires more in depth study.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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