© 2014 IJIRT | Volume 1 Issue 6 | ISSN : 2349-6002

DSP(Digital Signal Processing) IN ARRAY

Isha Batra, Divya Raheja
I.T. Department
Dronacharya College Of Engineering

***Abstract*- This paper deals with the continuous development of digital signal processing in the field of test and measurement .Digital signal processing (DSP) is concerned with the representation of signals by a sequence of numbers or symbols and the processing of these signals. DSP includes subfields like: audio and speech signal processing, sonar and radar signal processing, sensor array processing, spectral estimation, statistical signal processing, digital image processing, signal processing for communications, control of systems, biomedical signal processing, seismic data processing, etc. The goal of DSP is usually to measure, filter and/or compress continuous real-world analog signals. Today there are additional technologies used for digital signal processing including more powerful general purpose microprocessors, field-programmable gate arrays (FPGAs), digital signal controllers (mostly for industrial apps such as motor control), and stream processors, among others. the application of computational power to digital signal processing allows for many advantages over analog processing in many applications, such as error detection and correction in transmission as well as data compression. In addition, the various developments in digital filters in the field of digital signal processing is discussed.**

Index Terms- spectral estimation,statistical signal processing, FPGAs ,transmission.

I. INTRODUCTION

1) **Array Processing**: Signal processing is one of the most important research fields that affect every aspect of our lives. Signal processing is a wide area of research that extends from the simplest form of 1-D signal processing to the complex form of M-D and array signal processing. This article presents a short survey of the concepts, principles and applications of Array Processing. Array structure can be defined as a set of sensors that are spatially separated, e.g. antennas. The basic problem that we attend to solve by using array processing technique(s) is to:

- Determine number and locations of energy-radiating sources (emitters).
- Enhance the signal to noise ratio SNR "signal to interface plus noise ratio".

Track multiple moving sources. Array processing emerged in the last few decades as an active area and was centered on the ability of using and combining data from different sensors (antennas) in order to deal with specific estimation task (spatial and temporal processing). In addition to the information that can be extracted from the collected data the framework uses the advantage prior knowledge about the geometry of the sensor array to perform the estimation task. Array processing is used in radar, sonar, seismic exploration, anti-jamming and wireless communications. One of the main advantages of using array processing along with an array of sensors is a smaller foot-print. The problems associated with array processing include the number of sources used, their direction of arrivals, and their signal waveforms.

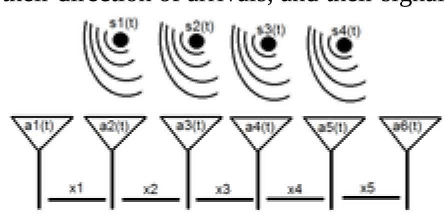


Fig 1. Sensors Array

There are four assumptions in array processing. The first assumption is that there is uniform propagation in all directions of isotropic and non-dispersive medium. The second assumption is that for far field array processing, the radius of propagation is much greater than size of the array and that there is plane wave propagation. The third assumption is that there is a zero mean white noise and signal, which shows uncorrelation. Finally, the last assumption is that there is no coupling and the calibration is perfect.

II. APPLICATIONS

The ultimate goal of sensor array signal processing is to estimate the values of parameters by using available temporal and spatial information, collected through sampling a wavefield with a set of antennas that have a precise geometry description. The processing of the captured data and information is done under the assumption that the wavefield is generated by a finite number of signal sources (emitters), and contains information about signal parameters characterizing and describing the sources. There are many applications related to the above problem formulation, where the number of sources, their directions and locations should be specified. To motivate the reader, some of the most important applications related to array processing will be discussed.

- **Radar and Sonar Systems**:

array processing concept was closely linked to radar and sonar systems which represent the classical applications of array processing. The antenna array is used in these systems to determine location(s) of source(s), cancel interference, suppress ground clutter. **Radar Systems** used basically to detect objects by using radio waves. The range, altitude, speed and direction of objects can be specified. Radar systems started as military equipments then entered the civilian world. In radar applications, different modes can be used, one of these modes is the active mode. In this mode the antenna array based system radiates pulses and listens for the returns. By using the returns, the estimation of parameters such as velocity, range and DOAs (direction of arrival) of target of interest become possible. Using the passive far-field listening arrays, only the DOAs can be estimated. **Sonar Systems** (Sound Navigation and Ranging) use the sound waves that propagate under the water to detect objects on or under the water surface.

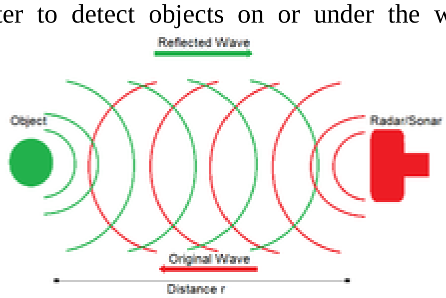


Fig 2.Radarsystem

- **Communications (wireless)**

Communication can be defined as the process of exchanging of information between two or more parties. The last two decades witnessed a rapid growth of wireless communication systems. This success is a result of advances in communication theory and low power dissipation design process. In general, communication (telecommunication) can be done by technological means through either electrical signals (wired communication) or electromagnetic waves (wireless communication). Antenna arrays have emerged as a support technology to increase the usage efficiency of spectral and enhance the accuracy of wireless communication systems by utilizing spatial dimension in addition to the classical time and frequency dimensions. Array processing and estimation techniques have been used in wireless communication.

Fig 3. Multi-Path Communication Problem in wireless communication Systems

- **Medical applications**

Array processing techniques got on much attention from medical and industrial applications. In medical applications, the medical image processing field was one of the basic fields that use array processing. Other medical applications that use array processing: diseases treatment, tracking waveforms that have information about the condition of internal organs e.g. the heart, localizing and analyzing brain activity by using bio-magnetic sensor arrays.

- **Array Processing for Speech Enhancement**

Speech enhancement and processing represents another field that has been affected by the new era of array processing. Most of the acoustic front end systems became fully automatic systems (e.g. telephones). However, the operational environment of these systems contains a mix of other acoustic sources; external noises as well as acoustic couplings of loudspeaker signals overwhelm and attenuate the desired speech signal. In addition to these external sources, the strength of the desired signal is reduced due to the relatively distance between speaker and microphones. Array processing techniques have opened new opportunities in speech processing to attenuate noise and echo without degrading the quality of and affecting adversely the speech signal. In general array processing techniques can be used in speech processing to reduce the computing power (number of computations) and enhance the quality of the system (the performance).

- **Array Processing in Astronomy Applications**

Astronomical environment contains a mix of external signals and noises that affect the quality of the desired signals. Most of the arrays processing applications in astronomy are related to image processing. The array used to achieve a higher quality that is not achievable by using a single channel. The high image quality facilitates quantitative analysis and comparison with images at other wavelengths. In general, astronomy arrays can be divided into two classes: the beamforming class and the correlation class. Beamforming is a signal processing techniques that produce summed array beams from a direction of interest – used basically in directional signal transmission or reception- the basic idea is to combine elements in a phased array such that some signals experience destructive inference and other experience constructive inference. Correlation arrays provide images over the entire single-element primary beam pattern, computed off-line from records of all the possible correlations between the antennas, pairwise.

- **Other applications**

In addition to these applications, many applications have been developed based on array processing techniques: Acoustic Beamforming for Hearing Aid Applications, Under-determined Blind Source Separation Using Acoustic Arrays, Digital 3D/4D Ultrasound Imaging Array, Smart Antennas, Synthetic aperture radar, underwater acoustic imaging, and Chemical sensor arrays...etc.

III. GENERAL MODEL AND PROBLEM FORMULATION

Consider a system that consists of array of **r** arbitrary sensors that have arbitrary locations and arbitrary directions (directional characteristics) which receive signals that generated by **q** narrow band sources of known center frequency ω and locations θ1, θ2, θ3, θ4 … θq. since the signals are narrow band the propagation delay across the array is much smaller than the reciprocal of the signal bandwidth and it follows that by using a complex envelop representation the array output can be expressed (by the sense of superposition) as:

$$x(t) = \sum_{K=1}^{q} a(\theta_k) s_k(t) + n(t)$$

Where:

- X(t) is the vector of the signals received by the array sensors.
- Sk(t): is the signal emitted by the kth source as received at the frequency sensor 1 of the array.
- a(θk): is the steering vector of the array toward direction (θk).
- τi(θk): is the propagation delay between the first and the ith sensor for a waveform coming from direction (θk).
- N(t) is the noise vector.

The same equation can be also expressed in the form of vectors:

$$\mathbf{x}(t) = A(\theta) s(t) + n(t)$$

If we assume now that M snapshots are taken at time instants t1, t2 … tM, the data can be expressed as:

$$\mathbf{X} = \mathbf{A}(\theta)\mathbf{S} + \mathbf{N}$$

Where X and N are the r × M matrices and S is q × M:

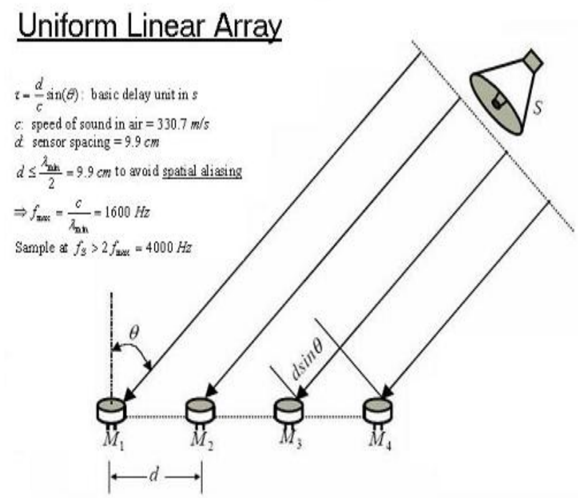
$$\mathbf{X} = [x(t_1), ..., x(t_M)]$$
$$\mathbf{N} = [n(t_1), ..., n(t_M)]$$
$$\mathbf{S} = [s(t_1), ..., s(t_M)]$$

Problem definition

“The target is to estimate the DOA’s θ1, θ2, θ3, θ4 …θq of the sources from the M snapshot of the array x(t1)… x(tM). In other words what we are interested in is estimating the DOA’s of emitter signals impinging on receiving array, when given a finite data set {x(t)} observed over t=1, 2 … M. This will be done basically by using the second-order statistics of data”

In order to solve this problem (to guarantee that there is a valid solution) do we have to add conditions or assumptions on the operational environment and\or the used model? Since there are many parameters used to specify the system like the number of sources, the number of array elements …etc. are there conditions that should be met first? Toward this goal we want to make the following assumptions

1. The number of signals is known and is smaller than the number of sensors, q<r.



2. The set of any q steering vectors is linearly independent.
3. Isotropic and non-dispersive medium – Uniform propagation in all directions.
4. Zero mean white noise and signal, uncorrelated.
5. Far-Field.
a. Radius of propagation >> size of array.
b. Plane wave propagation.

Throughout this survey, it will be assumed that the number of underlying signals, q, in the observed process is considered known. There are, however, good and consistent techniques for estimating this value even if it is not known.

IV. ESTIMATION TECHNIQUES

In general, parameters estimation techniques can be classified into: **spectral based and parametric based methods**. In the former, one forms some spectrum-like function of the parameter(s) of interest. The locations of the highest (separated) peaks of the function in question are recorded as the DOA estimates. Parametric techniques, on the other hand, require a simultaneous search for all parameters of interest. The basic advantage of using the parametric approach comparing to the spectral based approach is the accuracy, albeit at the expense of an increased computational complexity.

Spectral–Based Solutions

Spectral based algorithmic solutions can be further classified into beamforming techniques and subspace-based techniques.

Beamforming technique

The first method used to specify and automatically localize the signal sources using antenna arrays was the beamforming technique. The idea behind beamforming is very simple: steer the array in one direction at a time and measure the output power. The steering locations where we have the maximum power yield the DOA estimates. The array response is steered by forming a linear combination of the sensor outputs.

Approach overview

Where Rx is the sample covariance matrix. Different beamforming approaches correspond to different choices of the weighting vector F. The advantages of using beamforming technique are the simplicity, easy to use and understand. While the disadvantage of using this technique is the low resolution.

Subspace-based technique

Many spectral methods in the past have been called upon the spectral decomposition of a covariance matrix to carry out the analysis. A very important breakthrough came about when the eigen-structure of the covariance matrix was explicitly invoked, and its intrinsic properties were directly used to provide a solution to an underlying estimation problem for a given observed process. A class of spatial spectral estimation techniques is based on the eigen-value decomposition of the spatial covariance matrix. The rationale behind this approach is that one wants to emphasize the choices for the steering vector a(θ) which correspond to signal directions. The method exploits the property that the directions of arrival determine the eigen structure of the matrix. The tremendous interest in the subspace based methods is mainly due to the introduction of the MUSIC (Multiple Signal Classification) algorithm. MUSIC was originally presented as a DOA estimator, then it has been successfully brought back to the spectral analysis/system identification problem with it is later development.

V. CONCLUSION

Array processing technique represents a breakthrough in signal processing. Many applications and problems which are solvable using array processing techniques are introduced. In addition to these applications within the next few years the number of applications that include a form of array signal processing will increase. It is highly expected that the importance of array processing will grow as the automation becomes more common in industrial environment and applications, further advances in digital signal processing and digital signal processing systems will also support the high computation requirements demanded by some of the estimation techniques.In this article we emphasized the importance of array processing by listing the most important applications that include a form of array processing techniques. We briefly describe the different classifications of array processing, spectral and parametric based approaches.

REFERENCES

[1] Torlak, M. Spatial Array Processing. Signal and Image Processing Seminar. University of Texas at Austin.

[2] P Stoica, R Moses (2005; Chinese Edition, 2007). *SPECTRAL ANALYSIS OF SIGNALS* NJ: Prentice Hall.

[3] J Li, P Stoica (Eds) (2006). *ROBUST ADAPTIVE BEAMFORMING*. USA: J Wiley&Sons.

[4] Jha, RakeshMohan (2012), *Trends in Adaptive Array Processing*"Improving IMS array processing" Norsar.no. Retrieved 2012-08-06.

[5] Viberg, Mats (1995), *Sensor Array Signal Processing: Two Decades Later*

[6] Aaron Parsons, Donald Backer, Andrew Siemion (September 12, 2008). *A Scalable Correlator Architecture Based on Modular FPGA Hardware, Reuseable Gateware*,

[7] Wikipedia.org

[8] http://matlabsproj.blogspot.in/2012/05/array-signal-processing.html