PERFORMANCE EVALUATION OF CORRELATIVE INTERFEROMETRY FOR ANGLE OF ARRIVAL ESTIMATION

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To my honoured and esteemed family, friends and
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ABSTRACT

Radio direction finders are used to determine the direction of emitters and they are used by regulatory bodies, law enforcement, public safety and the Military. Bearings from multiple direction finders can be used by the process of triangulation to determine the position of emitters. There are several methods for radio direction finding; Watson Watt/Adcock method, Differential Doppler, Directional Antenna and Correlative Interferometry. The project proposes the implementation of Correlative Interferometry for angle of arrival (AOA) estimation. The Correlative Interferometry processing involves the comparison of the measured phase differences between the antenna elements of the direction finder (DF) antenna system with those obtained for the same antenna system at all possible directions of incidence. The comparison is made by calculating the correlation of the two data sets (or the scalar product of two vectors obtained by multiplying the coordinates element by element and summing the result). Using different comparison data sets for different wave directions, the bearing is estimated from the data set for which the correlation is at a maximum. Various configuration of the algorithm is investigated so that that the amount of processing and memory was optimized with accuracy in the measurement of the direction. From the optimum structure, Monte Carlo simulation is carried out to evaluate the mean and variance of multiple AOA estimates for various signal-to-noise ratios (SNR).

ABSTRAK

Radio arah pencari digunakan untuk menentukan arah pemancar dan ia digunakan oleh badan-badan regulatori, penguatkuasaan undang-undang, keselamatan dan ketenteraan awam. Galas dari pelbagai arah pencari boleh digunakan oleh proses Triangulasi untuk menentukan kedudukan pemancar. Terdapat beberapa kaedah untuk radio arah Penemuan; kaedah Watson Watt/Adcock, Pembezaan Doppler, antena berarah dan interferometri yg berhubung. Projek ini mencadangkan pelaksanaan interferometri yg berhubung bagi sudut ketibaan (AOA) anggaran. Pemprosesan interferometri berhubung dgn melibatkan perbandingan perbezaan fasa diukur antara unsur-unsur daripada antena pencari arah (DF) sistem antena dengan yang diperolehi untuk sistem antena yang sama pada semua arah yang mungkin kejadian. Perbandingan itu dibuat dengan mengira korelasi kedua-dua set data (atau produk skalar dua vektor diperolehi dengan mendarabkan unsur koordinat dengan elemen dan menjumlahkan hasilnya). Menggunakan perbandingan berbeza set data untuk arah gelombang yang berbeza, galas dianggarkan daripada set data yang mana korelasi adalah pada maksimum. Konfigurasi pelbagai algoritma disiasat supaya bahawa jumlah pemprosesan dan memori telah dioptimumkan dengan ketepatan dalam ukuran arahan itu. Dari struktur optimum, simulasi Monte Carlo dijalankan untuk menilai min dan varians bagi pelbagai AOA menganggarkan untuk nisbah pelbagai isyarat-kepada -hingar (SNR).

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CHAPTER 1

INTRODUCTION

1.1 Introduction

A radio direction finding (RDF) system is a passive device needed in various application fields such as navigation, military intelligence, geolocation, communication for emitter locating and targeting for weapon system [1]. Due to radio's ability to travel very long distances and "over the horizon", it makes a particularly good navigation system for ships, small boats, and aircrafts that might be at some distance from their destination. This can refer to radio or other forms of wireless communications. By combining the direction information from two or more suitably spaced receivers (or a single mobile receiver), the source of a transmission may be located in space via triangulation method.

The RDF determines the direction of arrival (AOA) of incoming signals of distant emitters. There are many traditional techniques that can determine the AOA such as Watson-Watt, differential Doppler [2], but the interferometer has the highest accuracy of measurement and which will be used for this project.

1.2 Problem Statement

- Existing direction finders tends to give error due to multipath fading and mutual coupling of antenna elements which results in ambiguities on estimating the AOA and also gives high error in the presence of noise.
- High processing burden accrued from implementing one big look-up table of all possible direction.
- The need for a robust, flexible and more accurate technique for estimating the location of emitters.

1.3 Objectives

The objectives of the work are described as follows;

- To design a correlative interferometer using a uniform linear array (ULA) that provides 180 degrees angle coverage for angle of arrival (AOA) estimation of all incident narrowband RF signals.
- To partition the algorithm into 2 levels: coarse scan and fine AOA estimate.
- To evaluate the performance of 4 and 8 element ULA AOA estimation in the presence of noise.
- To run Monte Carlo simulation for various SNR to determine and compare the accuracy of the two systems.

1.4 Scope

The scope of the work is

- Linear array antenna arrangement will be considered.
- The signal is down converted to baseband and system will be implemented on MATLAB.
- Hardware implementation is not considered. MATLAB® is used to develop the algorithm.
- A passive single platform source locator equipped with the sensor arrays is used.
- Multiple AOA estimates will be used for signal source locating and triangulation.
- System estimates one AOA at a time.

1.5 Research Methodology

First and foremost, literature review on the various direction finding techniques with emphasis on the correlative interferometer is carried out in order to have the current state-of-the-art background related to the objectives and problems needed to be solved in the project.

Multiple narrowband plane wave signals for different directions from the emitter are incidented on a uniform linear array (ULA) of the antenna. Phase differences (PD) are calculated between signal of a reference element and signals of the remaining elements in the array. The algorithms for the correlative interferometer direction finder are then developed to estimate the angle of arrival (AOA) based on the PD and data set of a look-up table.

Monte Carlo simulation for various signal-to-noise ratios (SNR) is performed to determine and evaluate the accuracy of the AOA estimation system. The algorithms are constructed and developed using MATLAB®.

1.6 Organization of the Project

Chapter 2 of the project deals with a brief overview on historical background of direction finder (DF) technology. This chapter covers a brief description of the different DF techniques. At the end of this chapter the principle of Interferometer and some literature on Monte-Carlo simulation has been covered which has been utilised for designing of DF system.

Chapter 3 describes the methodology required to design and implement the Correlative Interferometer DF system. It discusses the parameters needed to build the angle of arrival (AOA) estimation algorithm and the generation of the signals used for the estimation.

Chapter 4 looks and then examines and evaluate the performance results obtained: mean and variance of the (AOA) from Monte-Carlo simulation for a range of signal-to-noise-ratio. Various aspects of these results are discussed. And finally Chapter 5 discusses the conclusion and future recommendations for the project.

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