PHASE DIFFERENCE OF ARRIVAL RANGE ESTIMATION TECHNIQUE

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To My Parents

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ABSTRACT

Range estimation is an integral part of all localization techniques. Range information is usually inferred from strength of received signal, time of arrival and time-difference of arrival. The uncertainty in estimation may be caused by noise and multipath effect. This work focuses on range estimation on the basis of phase-difference of arrival (PDoA) where the target source employs a dual-frequency transmission as in case of dual-frequency radars. The range estimation in this technique is constrained by the difference in frequency and the level of synchronization between the two transmitted signals. In order to quantify the impact of these two limitations, a measurement setup, based on USRP (Universal Software Radio Peripheral) devices will be used. Two synchronized collocated USRP transmitters will be used as source and another USRP (with two receivers) will be used for range estimation at a distance. The measurements will be taken in a line-of-sight environment. The final report would present the results of simulation showing the relation between frequency difference and maximum unambiguous distance. A comparison between simulation results and field measurements will then be presented. The conclusions drawn from the data would pave the way for further investigation in multipath environment.

ABSTRAK

Anggaran jarak adalah merupakan sebahagian daripada semua teknik penyetempatan. Maklumat jarak biasanya disimpulkan daripada kekuatan isyarat yang diterima, masa ketibaan dan perbezaan masa ketibaan. Ketidakpastian dalam anggaran mungkin disebabkan oleh gangguan isyarat dan kesan pantulan isyrat dari pelbagai arah. Kerja ini memberikan tumpuan kepada pelbagai anggaran berdasarkan perbezaan fasa ketibaan (PDoA), di mana sumber sasaran menggunakan transmisi dwi-frekuensi seperti dalam kes radar dwi-frekuensi. Anggaran julat dalam teknik ini dikekang oleh perbezaan dalam kekerapan dan tahap penyegerakan antara kedua-dua isyarat dihantar. Dalam usaha untuk mengukur kesan daripada dua batasan, persediaan pengukuran, berdasarkan USRP (Software Universal Radio Peripheral) peranti akan digunakan. Dua frekuensi disegerakkan oleh pemancar USRP akan digunakan sebagai sumber dan USRP lain (dengan dua penerima) akan digunakan untuk pelbagai anggaran pada satu jarak. Ukuran akan diambil dalam persekitaran yang tiada halangan. Laporan akhir akan membentangkan keputusan simulasi menunjukkan hubungan antara perbezaan frekuensi dan jarak maksimum. Perbandingan keputusan simulasi dan ukuran lapangan kemudiannya akan dibentangkan. Kesimpulan yang diambil dari data akan membuka jalan untuk siasatan lanjut dalam persekitaran pelbagai arah.

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LIST OF ABBREVIATIONS

AOA	Angle of Arrival
RIPS	Radio Interferometric Positioning System
RSSI	Received Signal Strength Indicator
USRP	Universal Software Defined Radio Peripheral
WSN	Wireless Sensor Networks

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CHAPTER 1

INTRODUCTION

1.1 Overview

Object localization using radio frequencies has been applied in many practical applications in the area of sensor networks, radar imaging, indoor object tracking and wildlife monitoring. Various localization techniques are suggested in the literature based on signal strength, time of arrival and angle of arrival measurements.

There are various range-based localization algorithms for localization. In range-based methods, range information is estimated on the basis of signal strength with the help of multiple transmitters and/or receivers. Ambiguity in the estimates arises due to noise, multipath and shadowing and errors in electronics (like phase noise, jitter).

Some of the techniques infer range estimation from time of arrival (TOA) [10], radio interferometric positioning system (RIPS) [7] and phase difference of arrival (PDoA) as in the case of dual-frequency radars.

This project focuses on PDoA technique for range estimation. Here a setup, composed of dual-frequency transmitters (e.g. two USRP devices) and a distant receiver making the estimate of the distance, is suggestedThis situation illustrated in

figure 1.1 and Figure 1.2 captured in GNU Radio Companion (GRC) environment for unsynchronized and synchronized transmitters.

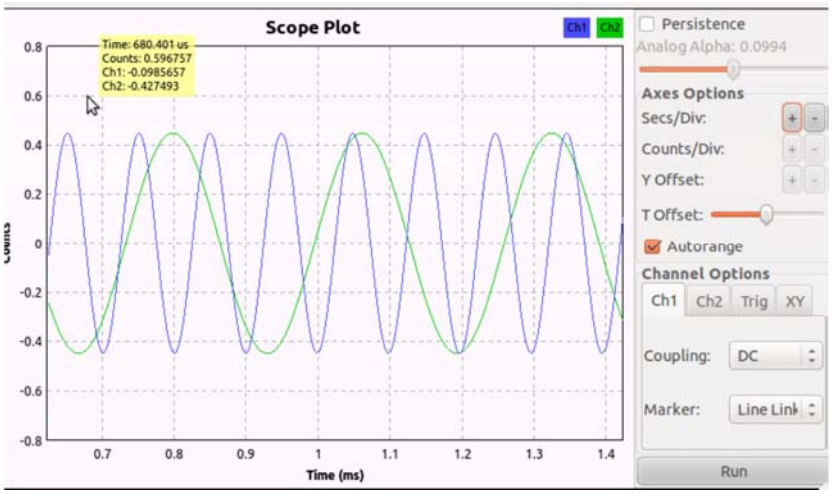

Figure 1.1 Phase Difference between Two Sinusoids

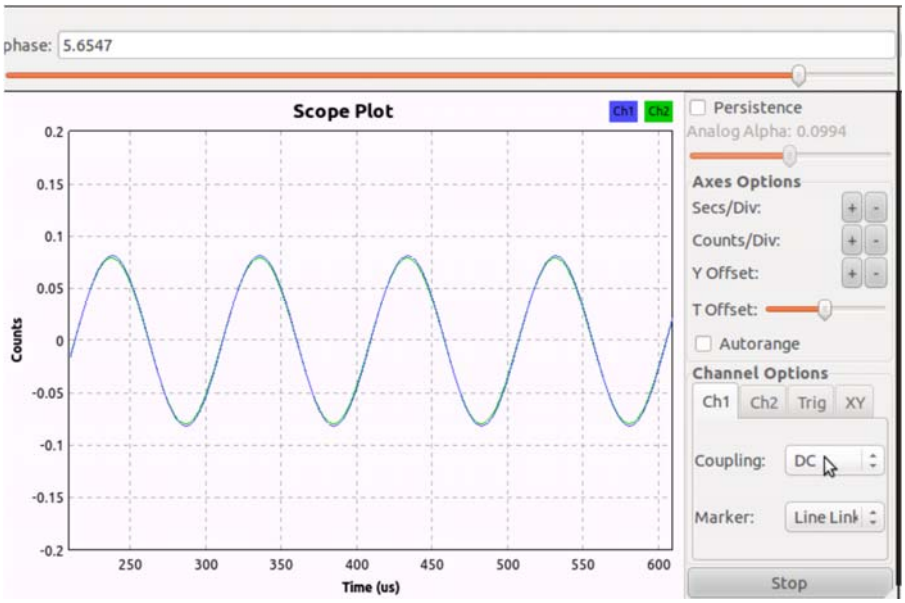

Figure 1.2 Zero Phase Difference between Two Sinusoids

If the frequencies of two transmitters have a slight difference, there will be a time-varying phase difference between signals arrived at a distant receiver. This resulting phase difference, as illustrated in Figure 1.3, is used in making range calculation (within modulo-2π limits) in PDoA technique that is being evaluated in this project.

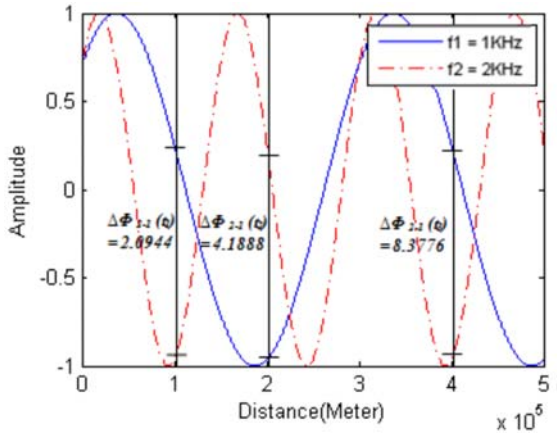

Figure 1.3 Phase Different Of Two Signals With Time

The synchronization between transmitters would therefore increase the confidence in range estimation made at the receiver. Once this is accomplished, the study may be extended to resolve estimation in multipath situation.

1.2 Problem Statement

All the techniques require use of multiple receivers (and transmitters in case of RIPS) and accuracy is dependent on the effects due to the multipath. Moreover, AOA, TDOA and RSSI techniques use single frequency whereas RIPS requires transmission at two frequencies which is similar to the range estimation done using dual frequency radars as suggested in [3]. Accuracy of dual frequency based ranging is highly dependent on the phase between the two transmitters because the ranging information is extracted from the phase difference between signals at a distance where estimation is being done. Thus, a phase extraction algorithm will be designed in order to calculate the phase and from that information, the range will be inferred.

1.3 Objectives of Project

To observe the phase difference which incurs due to the frequency difference of the two transmitting signals.

I. To measure the range from the observed phase difference.
II. Studying the effects of various parameters, which effect the range.
III. To observe the problem related to the synchronization.

1.4 Scope of the Project

I. Simulate range estimation using PDoA using MATLAB
II. Field measurement using four B-100 USRPs for the measurement of phase.
III. Extract the phase different and estimate the range using MATLAB for different distances.

1.5 Thesis Organization

This thesis consists of five chapters. This thesis shows the milestone achieved. Chapter 2, covers various representative location approaches that are found in literature. This chapter lays down the perspective of the problem addressed in this project. Chapter 3 delineates the project strategy that is used to achieve the objective. It may be noted that major bulk of this project is covered in Phase-2 of the project. Later in chapter 4, the procedure for taking the measurements and evaluation the possibilities for different range has been discussed. The next chapter presents the results and discussion obtained from the developed experimental setup. The problems and challenges faced during this research are also included in chapter 5. Finally, a conclusion of the entire research and some recommendations for future improvements are given in Chapter 6.

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