RESOLUTION ISSUES IN RADAR SIGNAL ANALYSIS

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To my parents, Hector Ochoa Ramirez and Ma. del Carmen Gutierrez Arthur, my Siblings, and Fara

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ABSTRACT

Classical work in the field of high-resolution radar often assumes that an echo signal is made of a number of components that can be decomposed via Fourier analysis. Adjacent components are said to be resolved in the frequency domain if the intensity between them drops at least 3 decibels. This working definition is an extension of Lord Rayleigh's criterion for optical resolution. The problem with this approach is that whereas Rayleigh's criterion assumes signal incoherence, a high-resolution radar signal is is often the coherent sum of sinusoids. The purpose of this thesis is to discuss the consequences of using Rayleigh's criterion in the analysis of radar signals. Specifically, computer simulations using a complex signal is analyzed via the periodogram as the relative phase between the two components of the signal is allowed to change. The net effect introduced by this phase variation is to reduce or increase the spacing and intensity between two adjacent spectral peaks. These changes are due to constructive or destructive interference of spectral cross terms that cannot be ignored when attempting to resolve frequency components from one another. Thus, the use of Rayleigh's criterion to define the resolution of a high-resolution radar system is inappropriate since phase difference information determines the relative range and relative doppler of a multi-component target.

TABLE OF CONTENTS

ACKNOWLEDGMENTS vi

ABSTRACT vii

LIST OF TABLES x

LIST OF FIGURES xi

1 INTRODUCTION **1**

2 RESOLUTION AND ACCURACY IN PHYSICS **3**

2.1 Introduction 3

2.2 Optics 3

2.3 Accuracy (Uncertainty) in Quantum Mechanics 5

3 FOURIER ANALYSIS **9**

3.1 Introduction 9

3.2 Fourier Transform 10

3.3 Temporal Windows and Spectra 14

3.4 Spectral Estimators 24

4 RANGE AND DOPPLER RESOLUTION **33**

4.1 Introduction 33

4.2 Range and Doppler Resolution 33

5 CONCLUSIONS 48

APPENDIX A 50

BIBLIOGRAPHY 54

CURRICULUM VITAE 57

List of Tables

3.1 Characteristics of common windows 24

3.2 Mean, standard deviation, and variance of various spectral estimations 26

List of Figures

2.1 Spectra separated by $\delta\lambda$ 5

3.1 Section of sine function (0 to 1 second) 11

3.2 Spectrum of sine function (1 second segment) 11

3.3 Section of sine function (0 to 3 seconds) 12

3.4 Spectrum of sine function (3 second segment) 12

3.5 Rectangular window 15

3.6 Spectrum of a rectangular window 15

3.7 Triangular window 16

3.8 Spectrum of a triangular window 17

3.9 Temporal Hann window with $\alpha = 1$ 18

3.10 Hann window spectrum with $\alpha = 1$ 18

3.11 Temporal Hann window with $\alpha = 2$ 19

3.12 Hann window spectrum with $\alpha = 2$ 19

3.13 Temporal Hann window with $\alpha = 3$ 20

3.14 Hann window spectrum with $\alpha = 3$ 20

3.15 Temporal Hann window with $\alpha = 4$ 21

3.16 Hann window spectrum with $\alpha = 4$ 21

3.17 Hamming window 22

3.18 Spectral Hamming window 23
3.19 Overlaid periodograms for N=20 samples 27
3.20 Ensemble mean of 50 periodograms (N=20) 27
3.21 Overlaid periodograms for N=100 samples 28
3.22 Ensemble mean of 50 periodograms (N=100) 28
3.23 Overlaid averaged periodograms for $K = 4$, $L = 64$ 29
3.24 Ensemble mean of 50 periodograms ($K = 4$, $L = 64$) 29
3.25 Overlaid averaged periodograms for $K = 8$, $L = 64$ 30
3.26 Ensemble mean of 50 periodograms ($K = 8$, $L = 64$) 30
3.27 Overlaid averaged periodogram for $K = 4$, $L = 64$, $O = 2$ 31
3.28 Ensemble mean of 50 periodograms with ($K = 4$, $L = 64$, $O = 2$) . . 31
3.29 Overlaid averaged periodograms for $K = 4$, $L = 64$, $O = 8$ 32
3.30 Ensemble mean of 50 periodograms with ($K = 4$, $L = 64$, $O = 8$) . . 32

4.1 Spectrum of signals independently evaluated 40
4.2 Superposition of spectra 40
4.3 Spectrum of signal ($\Delta\theta = 0^0$) 41
4.4 Spectrum of signal ($\Delta\theta = 45^0$) 41
4.5 Spectrum of signal ($\Delta\theta = 90^0$) 42
4.6 Periodogram with zero degrees phase 42
4.7 Periodogram with 45 degrees phase 43
4.8 Periodogram with 90 degrees phase 43
4.9 Average periodogram with zero degrees phase 44
4.10 Average periodogram with 45 degrees phase 44
4.11 Average periodogram with 90 degrees phase 45
4.12 Average periodogram overlapped with zero degrees phase 45

4.13 Average periodogram overlapped with 45 degrees phase 46
4.14 Average periodogram overlapped with 90 degrees phase 46
4.15 Change in magnitude of the local minimum between peaks (average periodogram) 47
4.16 Change in magnitude of the local minimum between peaks (average periodogram overlapped of temporal segments) 47

Chapter 1

INTRODUCTION

What is Resolution? This term, which is widely used in science and engineering, has a multitude of meanings. For instance, in astronomy, the term resolution is used in astronomy to define the resolving power of a telescope. In engineering, the term resolution can refer to the ability of a system to resolve two targets that are close to each other or the ability of an instrument to separate two or more spectral components of a signal.

In the context of Lord Rayleigh's Criterion, two spectral lines may be considered to be resolved if the principal maximum of the diffraction pattern of one line coincides with the first zero of diffraction pattern of the other line [8]. This criterion works well when the phase of a signal is of no consequence. For instance, in astronomy, the light that comes from distant stars is considered to be incoherent.

In the case of radar, the signals that come from the target are coherent and the phase has to be taken into consideration. Nevertheless, the concept of resolution in radar is often defined using the Rayleigh criterion. In doing this, the spectral cross terms, which are affected by phase differences between components, are effectively neglected. But why should they be ignored? Cross terms influence a target's range