

Contents

Chapter One

Introduction

1.1 General Remarks	1
1.2 Terminology	1
1.3 Signal Representation Using Orthogonal Functions	2
1.4 Book Outline	4
References	5
Problems	7

Chapter Two

Fourier Representation of Signals

2.1 Fourier Representation	9
2.2 Power, Amplitude, and Phase Spectra	12
2.3 Fourier Transform	16
2.4 Relation Between the Fourier Series and the Fourier Transform	18
2.5 Crosscorrelation, Autocorrelation, and Convolution	19
2.6 Sampling Theorem	25
2.7 Summary	28
References	29
Problems	29

Chapter Three

Fourier Representation of Sequences

3.1 Definition of the Discrete Fourier Transform	31
3.2 Properties of the DFT	32
3.3 Matrix Representation of Correlation and Convolution	37
3.4 Relation Between the DFT and the Fourier Transform Series	39
3.5 Power, Amplitude, and Phase Spectra	41
3.6 2-dimensional DFT	42
3.7 Time-varying Fourier Spectra	44
3.8 Summary	49
Appendix 3.1	50
References	51
Problems	52

Chapter Four

Fast Fourier Transform

4.1 Statement of the Problem	54
4.2 Motivation to Search for an Algorithm	54
4.3 Key to Developing the Algorithm	56
4.4 Development of the Algorithm	57
4.5 Illustrative Examples	64
4.6 Shuffling	69
4.7 Operations Count and Storage Requirements	70
4.8 Some Applications	71
4.9 Summary	78
Appendix 4.1 An FFT Computer Program	78
References	78
Problems	81

Chapter Five

A Class of Orthogonal Functions

5.1 Definition of Sequency	85
5.2 Notation	86
5.3 Rademacher and Haar Functions	87
5.4 Walsh Functions	89
5.5 Summary	94
Appendix 5.1 Elements of the Gray Code	94
References	95
Problems	96

Chapter Six

Walsh-Hadamard Transform

6.1 Walsh Series Representation	99
6.2 Hadamard Ordered Walsh-Hadamard Transform $(\text{WHT})_h$	102
6.3 Fast Hadamard Ordered Walsh-Hadamard Transform $(\text{FWHT})_h$	105
6.4 Walsh Ordered Walsh-Hadamard Transform $(\text{WHT})_w$	109
6.5 Fast Walsh Ordered Walsh-Hadamard Transform $(\text{FWHT})_w$	111
6.6 Cyclic and Dyadic Shifts	115
6.7 $(\text{WHT})_w$ Spectra	117
6.8 $(\text{WHT})_h$ Spectra	119
6.9 Physical Interpretations for the $(\text{WHT})_h$ Power Spectrum	123
6.10 Modified Walsh-Hadamard Transform (MWHT)	131
6.11 Cyclic and Dyadic Correlation/Convolution	137
6.12 Multidimensional $(\text{WHT})_h$ and $(\text{WHT})_w$	139
6.13 Summary	141
Appendix 6.1 WHT Computer Program	141
References	143
Problems	145

Chapter Seven

Miscellaneous Orthogonal Transforms

7.1 Matrix Factorization	153
7.2 Generalized Transform	156
7.3 Haar Transform	160
7.4 Algorithms to Compute the HT	160
7.5 Slant Matrices	163
7.6 Definition of the Slant Transform (ST)	167
7.7 Discrete Cosine Transform (DCT)	169
7.8 2-dimensional Transform Considerations	171
7.9 Summary	172
Appendix 7.1 Kronecker Products	172
Appendix 7.2 Matrix Factorization.	173
References	175
Problems	176

Chapter Eight

Generalized Wiener Filtering

8.1 Some Basic Matrix Operations	180
8.2 Mathematical Model	181
8.3 Filter Design	183
8.4 Suboptimal Wiener Filtering	186
8.5 Optimal Diagonal Filters	189
8.6 Suboptimal Diagonal Filters.	191
8.7 2-dimensional Wiener Filtering Considerations	194
8.8 Summary	194
Appendix 8.1 Some Terminology and Definitions.	195
References	197
Problems	197

Chapter Nine

Data Compression

9.1 Search for the Optimum Transform	200
9.2 Variance Criterion and the Variance Distribution	203
9.3 Electrocardiographic Data Compression	205
9.4 Image Data Compression Considerations	211
9.5 Image Data Compression Examples	213
9.6 Additional Considerations	219
9.7 Summary	220
Appendix 9.1 Lagrange Multipliers	221
References	222
Problems	222

Chapter Ten

Feature Selection in Pattern Recognition

10.1	Introduction	225
10.2	The Concept of Training	226
10.3	d-Dimensional Patterns	228
10.4	The 3-Class Problem	229
10.5	Image Classification Experiment	232
10.6	Least-Squares Mapping Technique	235
10.7	Augmented Feature Space	237
10.8	3-Class Least-Squares Minimum Distance Classifier	238
10.9	K-Class Least-Squares Minimum Distance Classifier	245
10.10	Quadratic Classifiers	248
10.11	An ECG Classification Experiment	249
10.12	Summary	253
	References	253
	Problems	254
Author Index		259
Subject Index		261