CONTENTS

Acknowledgements i
Contents ii-v
Nomenclature vi-vii
Symbols vii
Abbreviations ix
List of Figures x-xi
List of Tables xii
Abstract xiii-xv

1. Introduction 01-16
1.1. Speech Coding 01
1.2. Speech Production 02
1.3. Speech signal 03
   1.3.1. Time Domain Representation 03
   1.3.2. Frequency Domain Representation 03
1.4 Properties of Speech 06
1.5 Digital Encoding of Speech Signal 07
   1.5.1 Sampling 07
   1.5.2 Quantisation 07
      1.5.2.1 Scalar Quantisation 08
      1.5.2.2 Vector Quantisation 10
1.6 Thesis Organisation 14

2. Speech Coding and linear Prediction Analysis 17-39
2.1 Overview of Speech Coding Methods 17
   2.1.1. Introduction 17
   2.1.2. LPC-10 19
2.2 LP Analysis 20
   2.2.1 Background Theory 20
   2.2.2 Limitations of LP Analysis 23
   2.2.3 Spectral Analysis 24
   2.2.4 Fourier Analysis 25
   2.2.5 LPC Spectrum 28
2.2.6 Periodogram Spectrum 29
2.2.7 Conventional LP Analysis Methods 30
2.2.8 Determination of LP Parameters 32
2.3 Multipulse LPC 33
2.3.1 Pulse Computation 35
2.3.2 Pitch Prediction 36
2.4 Performance of LPC Coder 37
2.5 Conclusion 39

3. Filter Bank and Subband Transform 40-78
3.1 Introduction 40
3.2 Subband Coding Algorithms 40
  3.2.1 The Laplacian Pyramid 40
  3.2.2 Subband Coding Scheme 44
3.3 Design of Multirate Filter Banks 46
  3.3.1 Perfect Reconstruction Conditions 48
  3.3.2 Quadrature Mirror Filter 51
  3.3.3 Conjugate Mirror Filter 52
  3.3.4 Biorthogonal Filter 54
3.4 Subbands from Block Transform 55
  3.4.1 Discrete Cosine Transform 55
  3.4.2 Lapped Orthogonal Transform 58
  3.4.3 Modulated Lapped Transform 63
3.5 SPIHT (Set Partitioning in Hierarchical Trees) 65
  3.5.1 Parents and Children 65
  3.5.2 Working Principle 66
  3.5.3 Wavelet Bases 60
  3.5.4 Extension to More Dimensions 69
  3.5.5 Applications of Embedding 70
3.6 Implementation of SPIHT 71
3.7 Warped Linear Predictive Coding 74
  3.7.1 Introduction 74
  3.7.2 Frequency Warping 74
3.7.3 Warped LPC  
3.7.4 Warped Filter Structures  
3.8 Conclusion  

4. Human Hearing and Auditory Masking  
4.1 The Human ear  
4.1.1 The Outer Ear  
4.1.2 The Middle Ear  
4.1.3 The Inner Ear  
4.1.4 the Basilar Membrane and the Hair Cells  

4.2 Masking  
4.2.1 Threshold of Hearing  
4.2.2 Masking Effects  
4.2.3 Critical Bands and the Bark Scale  
4.2.4 Excitation Patterns and the Masking Threshold  
4.2.5 Psychoacoustic / Perceptual Coding  
4.2.5.1 The Sensitivity Threshold  
4.2.6 Simultaneous Masking  

4.3 Conclusion  

5. Analysis of Results  
5.1 Four Coding Schemes  
5.2 Plain LPC Coder  
5.3 Voice Excited LPC Coder  
5.4 MLT-SPIHT Coder  
5.4.1 Setting up the SPIHT Sets  
5.5 Masked MLT-SPIHT Coder  
5.6 Comparison and Analysis of the Scheme  
5.6.1 The Normalized Mean Squared Error  
5.6.2 Frequency Domain Interpretations of Linear Predictive Analysis  
5.6.3 Performance Analysis  
5.6.4 Computational Complexity  
5.6.5 Mean Opinion Score