Acknowledgments

Introduction

1 Basic Acoustics and Acoustic Filters
  1.1 The sensation of sound
  1.2 The propagation of sound
  1.3 Types of sounds
    1.3.1 Simple periodic waves
    1.3.2 Complex periodic waves
    1.3.3 Aperiodic waves
  1.4 Acoustic filters
Exercises

2 Digital Signal Processing
  2.1 Continuous versus discrete signals
  2.2 Analog-to-digital conversion
    2.2.1 Sampling
    2.2.2 Quantization
  2.3 Signal analysis methods
    2.3.1 Auto-correlation pitch tracking
    2.3.2 RMS amplitude
    2.3.3 Fast Fourier transform (FFT)
    2.3.4 Digital filters
    2.3.5 Linear predictive coding (LPC)
    2.3.6 Spectra and spectrograms
Exercises
## Contents

3 **Basic Audition**  
3.1 Anatomy of the peripheral auditory system 46  
3.2 The auditory sensation of loudness 47  
3.3 Frequency response of the auditory system 51  
3.4 Auditory representations 53  
Exercises 57

4 **Speech Perception**  
4.1 A speech perception experiment 59  
4.2 Maps from distances 64  
4.3 The perceptual map of fricatives 66  
4.4 The perceptual map of [place] 71  
4.5 The limits of perceptual universality: A cross-linguistic map of Chinese tones 74  
Exercises 78

5 **The Acoustic Theory of Speech Production: Deriving Schwa**  
5.1 Voicing 79  
5.2 Voicing quanta 82  
5.3 Vocal tract filtering 83  
5.4 Pendulums, standing waves, and vowel formants 85  
5.5 LPC spectral analysis 97  
Exercises 101

6 **Vowels**  
6.1 Tube models of vowel production 102  
6.2 Perturbation theory 107  
6.3 "Preferred" vowels – quantal theory and adaptive dispersion 111  
6.4 Vowel formants and the acoustic vowel space 113  
6.5 Auditory and acoustic representations of vowels 113  
6.6 Cross-linguistic vowel perception 117  
Exercises 119

7 **Fricatives**  
7.1 Turbulence 120  
7.2 Place of articulation in fricatives 124  
7.3 Quantal theory and fricatives 127  
7.4 Fricative auditory spectra 129  
7.5 Dimensions of fricative perception 132  
Exercises 133