Part IV
Applications of Data Processing
Several applications of data processing are included in this part. The five chapters cover areas of signal processing and information theory. Specifically the papers by Claussen et al., Patel et al., and Teolis et al. deal with audio signal processing, image signal processing, and eddy current signal processing, respectively. The paper by Tyagi et al. addresses a problem of channel coding.

The first chapter of this part is by Heiko Claussen, Justinian Rosca, Viswanathan Ramasubramanian, and Subramani Thiagarajan. The authors consider the signal detection problem where the signal of interest is corrupted additively by structured perturbations. Specifically, a set of measurements is collected as columns of a $D \times N$ matrix $X$. The authors estimate the signal of interest as the vector given by $w = X(X^TX + \lambda I)^{-1}1$, where $\lambda$ is a scalar that parameterizes the generalized mutual interdependence analysis (GMIA) solution. Next the authors apply this estimate to the problem of voice activity detection for hearing-aid devices. They compare performance of GMIA with MFCC and cepstral-mean features.

Vishal M. Patel and Rama Chellappa study shape and image reconstruction from gradient field information. In particular they discuss four methods: a Poisson-based method, a Fourier-based method (the Frankot–Chellappa algorithm), the shapelet approach, and a wavelet-based algorithm. In the second part of this chapter, the authors discuss image recovery from partial Fourier measurements using inversion of the estimated gradient field. Numerical comparisons with the inversion algorithm using total variation are also presented.

Anthony Teolis analyzes the linear system response to analytic signals, which are functions in the Hardy space $H^2$. Specifically, he considers input signals of the form $p(t) = A(t)e^{i\Phi(t)}$, where $\Phi(t) = 2\pi \int_0^t f(s) \, ds$. Here $f(s)$ denotes the instantaneous frequency. This chapter considers linear systems which are small perturbations of the identity; “small” is with respect to the operator norm on $L^2(\mathbb{R})$. The instantaneous frequency of the output signal is computed in terms of the input signal and the linear system impulse response. In the last part of the chapter, the author applies these results to two classes of signals: chirps and FM chirps.

The fourth chapter of this part is by Carole Teolis, David Gent, Christine Kim, Anthony Teolis, James Paduano, and Michelle Bright. The authors present an algorithm for gas turbine monitoring and stall detection using eddy current sensors. First, they analyze the eddy current sensor signal using a combination of band-pass filter center around the second harmonic, followed by a narrowband wavelet filterbank. The engine-dependent signature corresponds to the narrowband channel output where the maximum occurs. A simplified implementation of this algorithm uses the second derivative of the instantaneous phase, which is also the first derivative of the instantaneous frequency. The authors test these algorithms on real data obtained at the NASA Glenn W8 compressor test facility.

The last chapter of this part is by Himanshu Tyagi and Prakash Narayan. The authors discuss the fundamental problem of reliable channel coding in information theory. They consider the case of a state-dependent discrete memoryless channel with known underlying state process distribution. Additionally it is assumed that the transmitter knows the channel state. Two classical results on state-dependent
channel capacity are due to Shannon (when the encoder is causal) and Gelfand and Pinsker (when the encoder is noncausal). It was known that Shannon’s result admits a strong converse. The authors prove a strong converse for the Gelfand–Pinsker theorem. During this exposition they also obtain upper bounds on the reliability function (the exponent for which transmission error decays to zero) for both channel models.