Chapter 3
Trend Analysis Using the Frazier-Jawerth Transform

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Abstract

This chapter discusses the Frazier-Jawerth Transform (FJT), a new transform for time-frequency analysis (Frazier and Jawerth, 1985) and a new method for its on-line implementation. Algorithms for FJ decomposition and reconstruction of 1-D signals are also included. FJT bears close resemblance to the wavelet transform technique which is enjoying much attention lately (Science, August 1990). The theory of frames has been shown to subsume the FJ and the wavelet transforms (Heil and Walnut, 1989). It is now widely believed that these new time-frequency techniques may replace the Fourier transform and older time-frequency techniques in some applications in future. Potential applications of interest to chemical engineers include analysis of dynamic systems, process control, solution of partial differential equations, geoexploration data processing, vibration/acoustic testing methods, artificial neural networks etc. FJT has been employed as a time-series data preprocessing mechanism in an artificial neural network based process trend and abnormality detection scheme.

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1 Introduction

The behavior of a dynamic system is usually studied by observing the evolution of a set of measured or state variables (signals) over time. The signals are usually analyzed to yield information about the state of the dynamic system. The analysis is done either entirely in the time domain (e.g. by calculating moments) or entirely in the frequency (or Fourier) domain. Such analysis is used for various purposes, e.g. to analyze system stability, to identify the system model. Time-domain analysis is a popular method for residence-time distribution studies in reaction engineering. Linear control theory and practice depends heavily on pure frequency domain analysis of systems.

In many applications of interest to chemical engineers, a joint time and frequency domain analysis would be helpful. Such analysis is especially useful if the signals are non-stationary or change their frequency content with time. Such signals are encountered in the analysis of dynamic chemical engineering systems. They are the norm in geoeexploratory analysis where signals which have passed through several layers of different properties (and have thus changed in frequency-content and also have delays associated with them) have to be analyzed. In vibration/ acoustic analyses of structural components (e.g. polymer composite structures) the changes in the nature of the test signal are analyzed for diagnosing material defects.

This paper discusses a novel technique, the Frazier-Jawerth transform (FJT) (Frazier and Jawerth, 1985, 1988, Kumar et al., 1992) which provides a joint time and frequency description (or a time-frequency description) of a signal. The treatment here will only include one-dimensional signals (the case which is of primary interest to chemical engineers) although the technique can be extended to the general case of N-dimensional signals. The analysis of two-dimensional signals (images) is of interest to the disciplines such as telecommunications and medical imaging. For the process industries, possible areas of application include process and structural fault diagnosis, geoeexploration, numerical solution of partial differential equations, process control and artificial neural network applications.

The primary aim of this chapter is to provide a self-contained introduction to the FJT and its computational algorithms and a new algorithm for its online implementation. That the FJT enables a multiresolution description of a