

Programs for Digital Signal Processing

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Preface

During the past fifteen years, digital signal processing has been an extremely active and dynamic field. Advances in integrated circuit technology and in processor architecture have greatly enlarged the scope of the technical areas to which digital signal processing techniques can be applied. Research in fundamental signal processing techniques and algorithms has led to dramatic improvements in the efficiency of signal processing systems.

An important facet of the progress in digital signal processing has been the development of algorithms and their embodiment in computer programs, both for the execution of processing operations on signals and for the design of signal processing filters and systems. The purpose of this book is to make widely available, in a directly usable form, a comprehensive set of computer programs useful for digital signal processing. In addition, the book serves as an outlet for excellent programming effort and enables authors of programs to receive credit for their work.

The programs have been carefully selected to cover a broad spectrum of digital signal processing applications and design techniques. The programs are categorized into eight chapters, and separate summaries (authored by chapter editors who were also asked to make final checks on the documentation and code) are provided with each chapter. The first chapter focuses on the Discrete Fourier Transform (DFT) and presents a variety of Fast Fourier Transform (FFT) and related algorithms. Chapter 2 includes algorithms for the periodogram and correlation methods of power spectrum estimation and for coherence and cross spectrum estimation. A program for high speed, FFT-based convolution is presented in Chapter 3. Chapter 4 presents several algorithms related to the linear prediction techniques of signal processing, including the autocorrelation, covariance, and lattice methods. The design and synthesis of Finite Impulse Response (FIR) digital filters are the subjects of Chapter 5. Algorithms for optimal (minimax), windowed, and maximally-flat filter designs, and a design program which incorporates finite-word-length effects, are included. Chapter 6 presents a comprehensive set of programs dealing with the design and synthesis of Infinite Impulse Response (IIR) digital filters. The first program in that chapter includes most of the classical filter design techniques as well as consideration of finite word length issues such as pairing and ordering in a single but modular package. The other programs in that chapter are specialized either to the finite word length design problem or to filter design based on iterative optimization. Chapter 7 deals with cepstral and homomorphic algorithms, with specific attention to the difficult problem of phase calculation in a homomorphic system. Finally, Chapter 8 presents several programs for interpolation and decimation, the fundamental operations necessary for changing sampling rates in a digital system. Included are multistage implementations and sampling rate conversion by rational ratios.

The book is the culmination of a project undertaken in early 1976 by the Digital Signal Processing Committee of the IEEE Acoustics, Speech, and Signal Processing Society. In contrast to previous books in the IEEE Press reprint series, this book consists largely of material which has not been published before. In addition, a unique and complex set of issues regarding the publication of computer programs had to be dealt with. These issues included: (1) clarity and uniformity of documentation and program presentation; (2) independent review and verification of all programs; (3) portability and machine-independence of code; and (4) availability of computer-readable source programs. The project has therefore been a very ambitious and time-consuming one for the committee, for the program contributors, and for the reviewers.

In order to assess the feasibility of the project, the committee distributed to the digital signal processing community in early 1976 a description of the proposed project and a request for descriptions of candidate programs. The distribution of this request was carried out both through direct mailing and through handouts at the 1976 International Conference on Acoustics, Speech, and Signal Processing. In a short time, enough very promising candidate programs had been identified to convince the committee that the book was not only feasible, but potentially a landmark contribution to the digital signal processing field. In addition, a reasonable organization of the material into the eight sections now included in the book began to emerge.

Because of the large effort to be required of program contributors and of reviewers, it was deemed desirable to pre-screen program candidates based on the offered descriptions, and invite submission of only those programs judged most likely to fit our rather stringent requirements. In cases where two