

AN EXERCISE IN SIGNAL PROCESSING TECHNIQUES

Theodora Ananidou

Department of Geological Sciences, University of South Carolina, Columbia, SC
29208, doras@geol.sc.edu

Theofilos S. Sarris

Department of Geological Sciences, University of South Carolina, Columbia, SC
29208, sarris@geol.sc.edu

Ian Lerche

Department of Geological Sciences, University of South Carolina, Columbia, SC
29208, black@geol.sc.edu

ABSTRACT

An exercise in a course on signal processing techniques for students was the motivation to report some of the procedures on signal recovery capability so that other students can, perhaps, use them as an introduction to data analysis. This paper illustrates some of the procedures that can be used easily in order to extract "signal" and "noise" from a set of data. The rather unconventional dataset of the publication record with time of one of the authors has been used, and under specific assumptions for the set of data, smoothing routines were applied using 5, 7, 9, and 11-point running average smoothers. For the original and the smoothed data, the power spectra were calculated. Significant peaks at certain periods are observed irrespective of the smoothing procedure and presumably record historical event periods of some importance. In this example, the Blackman-Tukey theorem is employed regarding signal and noise resolution. The estimates of signal and noise power were integrated over the total frequency range to obtain a statistically stable estimate of the "signal", indicating that about 85% of the data are robust to variations in the processing techniques used.

Keywords: Education - Computer assisted, Education - Geoscience, Education - Science, Engineering and Environmental Geology, Geology, Geoscience, Geophysics, Science, World Wide Web

INTRODUCTION

As part of a course on signal processing techniques for students, one of the exercises was to take a provided record of data with time and to produce an assessment of whether the record contains a signal. The methods used were up to the discretion of each student but were to be quantified, and their assumptions and weaknesses noted and used to ensure a quantitatively accurate rendition of signal in the given record. As basic references for the students, the course used Davis (1986), Mendoe (1984), and Yarus and Chambers (1994), with ancillary references to journals being provided for a more comprehensive understanding of the subject (such as *Geophysics*, *Proceedings of the IEEE*, *IEEE Signal Processing Magazine*, *Journal of Geoscience Education*, *Journal of Geophysical Research*)

It occurred to us that it might be a good idea to record some of the procedures so that other students can obtain an idea of signal recovery capability with particular techniques. All the computer programs used are available free from the World Wide Web, so that there is virtually no cost involved in setting up the exercise or in its execution. The biggest problem is to provide a data set that has a "real" meaning, rather than, say, a data set that describes scientific measurements but for which the average student might have no understanding of what the data are supposed to represent physically.

To circumvent such different levels of understanding of different areas of science, the students were provided with the publication record with time of one of the authors (I.L.). This data set is something the students can immediately relate to as being "real", and also something that represents an on-going scientific report card of the various ups-and-downs in the scientific life of one individual (see later for a brief historical accounting of these peaks and valleys). This record of data was then to be examined using signal processing techniques for "signal" and "noise". We report here on those efforts.

TECHNICAL ASSUMPTIONS AND METHODS

The Data Base - The data were presented to the students in terms of the number of publications per year, as shown in figure 1. Note that this limitation means it is impossible to analyze the data on a timescale finer than a year (such would be possible if the actual dates of publication of each article had been used and not just the publication year). Because whole numbers of calendar years were used rather than fractional (so one counts publications in 1965, 1966, etc., rather than 1965.3-1966.3, 1966.3-1967.3, etc), then one already has some sort of bias in the data used on a year scale-length because of the arbitrary choice of integer year counting (this bias is removable by taking actual publication dates of articles rather than just the year of publication).

However, given the time constraints for the class, it was decided not to pursue this refinement of the data. It would have taken just too long to obtain the exact publication dates (day, month, year) for over 630 articles, some in rather obscure journals. So the basis for further signal processing manipulations was the data portrayed in figure 1. As an aside, because the students had the publications list, and because of the innate curiosity of students, they also plotted the publications by broad subject categories as shown in figure 2. A major shift from the category "Astrophysics" to the category

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Computer-based Exercises for Signal Processing Using MATLAB C. S. Burrus,1994 Use of Adaptive Signal Processing Techniques to Discriminate Between Coal Cutting and Rock Cutting Michael J. Pazuchanics,Gary L. Mowrey,1991

Signal Processing Techniques for Computational Health Informatics Md Atiqur Rahman Ahad,Mosabber Uddin Ahmed,2020-10-07 This book focuses on signal processing techniques used in computational health informatics As computational health informatics is the interdisciplinary study of the design development adoption and application of information and technology based innovations specifically computational techniques that are relevant in health care the book covers a comprehensive and representative range of signal processing techniques used in biomedical applications including bio signal origin and dynamics sensors used for data acquisition artefact and noise removal techniques feature extraction techniques in the time frequency time frequency and complexity domain and image processing techniques in different image modalities Moreover it includes an extensive discussion of security and privacy challenges opportunities and future directions for computational health informatics in the big data age and addresses the incorporation of recent techniques from the areas of artificial intelligence deep learning and human computer interaction The systematic analysis of the state of the art techniques covered here helps to further our understanding of the physiological processes involved and expandour capabilities in medical diagnosis and prognosis In closing the book the first of its kind blends state of the art theory and practices of signal processing techniques inthe health informatics domain with real world case studies building on those theories As a result it can be used as a text for health informatics courses to provide medics with cutting edge signal processing techniques or to introducehealth professionals who are already serving in this sector to some of the most exciting computational ideas that paved the way for the development of computational health informatics Digital Filters and Signal Processing Leland B. Jackson,1996 This text presents a general survey of digital signal processing concepts design methods and implementation considerations with an emphasis on digital filters It includes MATLAB exercises *The Designer's Guide to the Cortex-M Processor Family* Trevor Martin,2016-06-06 The Designer s Guide to the Cortex M Microcontrollers gives you an easy to understand introduction to the concepts required to develop programs in C with a Cortex M based microcontroller The book begins with an overview of the Cortex M family giving architectural descriptions supported with practical examples enabling you to easily develop basic C programs to run on the Cortex M0 M0 M3 and M4 and M7 It then examines the more advanced features of the Cortex architecture such as memory protection operating modes and dual stack operation Once a firm grounding in the Cortex M processor has been established the book introduces the use of a small footprint RTOS and the CMSIS DSP library The book also examines techniques for software testing and code reuse specific to Cortex M microcontrollers With this book you will learn the key differences between the Cortex M0 M0 M3 and M4 and M7 how to write C programs to run on Cortex M based processors how to make the best use of the CoreSight debug

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Mastering System Identification in 100 Exercises Johan Schoukens, Rik Pintelon, Yves Rolain, 2012-04-02 This book enables readers to understand system identification and linear system modeling through 100 practical exercises without requiring complex theoretical knowledge The contents encompass state of the art system identification methods with both time and frequency domain system identification methods covered including the pros and cons of each Each chapter features MATLAB exercises discussions of the exercises accompanying MATLAB downloads and larger projects that serve as potential assignments in this learn by doing resource

[Time-Frequency Signal Analysis and Processing](#) Boualem Boashash, 2015-12-11 Time Frequency Signal Analysis and Processing TFSAP is a collection of theory techniques and algorithms used for the analysis and processing of non stationary signals as found in a wide range of applications including telecommunications radar and biomedical engineering This book gives the university researcher and R a Getting Started chapter enabling readers to start using the algorithms on simulated and real examples with the TFSAP toolbox compare the results with the ones presented in the book and then insert the algorithms in their own applications and adapt them as needed Two new chapters and twenty three new sections including updated references New topics including efficient algorithms for optimal TFDs with source code the enhanced spectrogram time frequency modelling more mathematical foundations the relationships between QTFDs and Wavelet Transforms new advanced applications such as cognitive radio watermarking noise reduction in the time frequency domain algorithms for Time Frequency Image Processing and Time Frequency applications in neuroscience new chapter A comprehensive tutorial introduction to Time Frequency Signal Analysis and Processing TFSAP accessible to anyone who has taken a first course in signals Key advances in theory methodology and algorithms are concisely presented by some of the leading authorities on the respective topics Applications written by leading researchers showing how to use TFSAP methods

Biomedical Signal Analysis Rangaraj M. Rangayyan, Sridhar Krishnan, 2024-02-19 Biomedical Signal Analysis Comprehensive resource covering recent developments applications of current interest and advanced techniques for biomedical signal analysis Biomedical Signal Analysis provides extensive insight into digital signal processing techniques for filtering identification characterization classification and

analysis of biomedical signals with the aim of computer aided diagnosis taking a unique approach by presenting case studies encountered in the authors research work Each chapter begins with the statement of a biomedical signal problem followed by a selection of real life case studies and illustrations with the associated signals Signal processing modeling or analysis techniques are then presented starting with relatively simple textbook methods followed by more sophisticated research informed approaches Each chapter concludes with solutions to practical applications Illustrations of real life biomedical signals and their derivatives are included throughout The third edition expands on essential background material and advanced topics without altering the underlying pedagogical approach and philosophy of the successful first and second editions The book is enhanced by a large number of study questions and laboratory exercises as well as an online repository with solutions to problems and data files for laboratory work and projects Biomedical Signal Analysis provides theoretical and practical information on The origin and characteristics of several biomedical signals Analysis of concurrent coupled and correlated processes with applications in monitoring of sleep apnea Filtering for removal of artifacts random noise structured noise and physiological interference in signals generated by stationary nonstationary and cyclostationary processes Detection and characterization of events covering methods for QRS detection identification of heart sounds and detection of the dicrotic notch Analysis of waveshape and waveform complexity Interpretation and analysis of biomedical signals in the frequency domain Mathematical electrical mechanical and physiological modeling of biomedical signals and systems Sophisticated analysis of nonstationary multicomponent and multisource signals using wavelets time frequency representations signal decomposition and dictionary learning methods Pattern classification and computer aided diagnosis Biomedical Signal Analysis is an ideal learning resource for senior undergraduate and graduate engineering students Introductory sections on signals systems and transforms make this book accessible to students in disciplines other than electrical engineering

Journal of Geoscience Education ,1996 *Mathematical Methods and Algorithms for Signal Processing* Todd K. Moon,Wynn C. Stirling,2000 This previously included a CD The CD contents can be accessed via World Wide Web *Computer-based Exercises for Signal Processing Using MATLAB 5* James H. McClellan,1998 For senior or introductory graduate level courses in digital signal processing Developed by a group of six eminent scholars and teachers this book offers a rich collection of exercises and projects which guide students in the use of MATLAB v5 to explore major topical areas in digital signal processing [Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society](#) IEEE Engineering in Medicine and Biology Society. Annual Conference,1988 *Nonlinear Stochastic Mechanics* Nicola Bellomo,Fabio Casciati,2012-12-06 The Symposium held in Torino ISI Villa Gualino July 1 5 1991 is the sixth of a series of IUTAM Symposia on the application of stochastic analysis to continuum and discrete mechanics The previous one held in Innsbruck 1987 was mainly concentrated on qualitative and quantitative analysis of stochastic dynamical systems as well as on bifurcation and transition to chaos of deterministic systems This Symposium concentrated

on fundamental aspects stochastic analysis and mathematical methods on specific applications in various branches of mechanics engineering and applied sciences as well as on related fields as analysis of large systems system identification earthquake prediction Numerical methods suitable to provide quantitative results say stochastic finite elements approximation of probability distribution and direct integration of differential equations have also been the object of interesting presentations Specific topics of the sessions have been Engineering Applications Equivalent Linearization of Discrete Stochastic Systems Fatigue and Life Estimation Fluid Dynamics Numerical Methods Random Vibration Reliability Analysis Stochastic Differential Equations System Identification Stochastic Control We are indebted to the IUTAM Bureau for having promoted and sponsored this Symposium and the Scientific Committee for having collaborated to the selection of participants and lecturers as well as to a prompt reviewing of the papers submitted for publication into these proceedings A special thank is due to Frank Kozin the organization of this meeting was for him very important he missed the meeting but his organizer ability was present

Digital Signal Processing Jonathan Y. Stein, 2000-10-09 Get a working knowledge of digital signal processing for computer science applications The field of digital signal processing DSP is rapidly exploding yet most books on the subject do not reflect the real world of algorithm development coding for applications and software engineering This important new work fills the gap in the field providing computer professionals with a comprehensive introduction to those aspects of DSP essential for working on today's cutting edge applications in speech compression and recognition and modem design The author walks readers through a variety of advanced topics clearly demonstrating how even such areas as spectral analysis adaptive and nonlinear filtering or communications and speech signal processing can be made readily accessible through clear presentations and a practical hands on approach In a light reader friendly style *Digital Signal Processing A Computer Science Perspective* provides A unified treatment of the theory and practice of DSP at a level sufficient for exploring the contemporary professional literature Thorough coverage of the fundamental algorithms and structures needed for designing and coding DSP applications in a high level language Detailed explanations of the principles of digital signal processors that will allow readers to investigate assembly languages of specific processors A review of special algorithms used in several important areas of DSP including speech compression recognition and digital communications More than 200 illustrations as well as an appendix containing the essential mathematical background

A Functional Description of the Edvac [an Automatically-Sequence Serial Binary Electronic Digital Computer] Moore School of Electrical Engineering, 1949

Discover Signal Processing Simon Braun, 2008-04-15 Signal processing is now a multidisciplinary topic and one that has applications in many fields including but not limited to science engineering medicine finance and the behavioural sciences Modern software libraries that include dedicated languages and packages designed to simplify the development and application of signal processing techniques are now readily available however this ease of application means that an understanding of the various techniques is imperative It is critical that the student or practitioner

is able to choose an appropriate processing technique be aware of potential errors involved and understand how to control them Discover Signal Processing exploits the rationale of learning by doing actually attempting and performing a task is the most effective way to remember and understand It presents the reader with a diverse range of exercises some intended to recall or practice simple concepts others more complex Includes more than 60 exercises covering major aspects of signal processing tools Uses MATLAB as a platform utilizing its extensive GUI capabilities enabling exercises to be performed using graphical elements only Discover Signal Processing provides an excellent accessible guide to signal processing for mechanical aeronautical civil and electronic engineers in their senior graduate year It will also be of interest to those attending CPD courses as well as to practicing engineers

1999 IEEE International Conference on Acoustics, Speech, and Signal Processing, 1999 **Signal Processing Methods for Audio, Images and Telecommunications**
Peter M. Clarkson, Henry Stark, 1995-06-26 This work examines the applications of algorithms to audio video and telecommunications with special emphasis on wavelets digital filters neural nets image processing and acoustic processing

1997 IEEE International Conference on Acoustics, Speech, and Signal Processing, 1997 *Practical Signal Processing* Mark Owen, 2007-05-17 This book introduces the basic theory of digital signal processing with emphasis on real world applications

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