

Preface

Probably the most important technological invention of the previous century was the transistor. And another very important invention was the digital computer, which got a definitive boost with the advent of integrated transistor-based circuits. In the days when these creatures were born, it was foreseen a bright future for communication, control and computing. The three C's. What could be certainly said today is that there is an impressive plethora of digital processing devices being used by millions of people: smartphones, GPS, cameras, computers in all formats. Part of the future will be also service robots, internet of things, autonomous vehicles, etc. Most of these devices depend critically on digital signal processing, which is the theme of this book.

This is the second book of a trilogy. In the first book we took in consideration common signal processing functions, like filtering, or modulation, and a first view of non-stationary signals. Now, in this book, we pay attention to recent topics that respond to the needs of new digital technologies. As in the other book, a series of MATLAB programs are embedded in the chapters for several purposes: to illustrate the techniques, to provide implementation examples, to encourage for personal exploration departing from a successful start. The programs can be downloaded from the web, but it would be rewarding for the reader to re-type the programs (at least the shorter listings) in order to get more familiar with MATLAB coding.

The book has two parts. The first part includes four chapters and is devoted to decomposition and recovery of signals, with emphasis on images. The second part includes three chapters and deals with important data-based actions, such as adaptive filtering, experimental modeling, and classification.

The main contents of the first part are filter banks, wavelets, and images. While the Fourier transform is adequate for periodic signals, wavelets are more suitable for other cases, like for instance short-duration signals: bursts, spikes, tweets, lung sounds, etc. Both Fourier and wavelets transforms decompose signals into components. Both are also invertible, so original signals can be recovered from their components.

In general, the wavelets can be introduced emphasizing more or less the point of view of filtering, which is frequency-domain, or the point of view of mathematics,

which is mostly time-domain. We preferred to start with a filtering approach: signals are decomposed into sub-bands using filter banks. This is Chap. 1 of the book.

In Chap. 2, wavelets are introduced using an important example: the Haar wavelet. This wavelet can be implemented with a filter bank for real-time application. The same happens with other types of wavelets: they can be implemented with filter banks. Thus, Chaps. 1 and 2 are closely linked together.

One of the revolutions we are witnessing is digital images and videos. Wavelets are used in this context for compression, denoising, and certain analysis tasks (for instance in medical applications). Chapters 3 and 4 introduce fundamentals of digital image processing, and then apply filter banks and wavelets to images according with peculiar aspects, like for instance directional filtering, or JPEG compression.

Inside the matters covered in the first part of the book there is a basic problem that is analog to a problem of tiling. Suppose you want to cover with tiles the floor of a room. This could be done with triangular, rectangular, hexagonal tiles, but not with pentagonal tiles. Actually, there are not so many tile geometries that allow for exact covering. With signals something similar happens, they can be decomposed into components by certain types of filters, and then they can be recovered by re-combining these components. Not any filter can be used for that. This is a main aspect that motivates the title of the Part I.

Part II of the book embodies several topics having in common the protagonism conceded to data. The characteristics of signals or data are taken into account for adaptive filtering. The processing of input/output data can be used for establishing a dynamic model. And the classification of data can help to extract relevant information. Main topics of the second part are the Wiener filter, the recursive adaptive filters, the estimation of transfer functions or ARMA models, the estimation of principal or independent components of data, the Support Vector Machine for classification, the K-means algorithm, the Expectation–Maximization algorithm, the use of neurons, etc. Experiments about face recognition were included. Illustrative applications of adaptive filters are modem equalization, echo cancellation for the use of mobile phones inside cars, or the correction of motion-blurred pictures.

For easier reading of the book, the longer programs have been put in an appendix.

The reader is invited to discover the profound interconnections and commonalities that exist behind the variety of topics in this book. This common ground would become surely the humus for the next signal processing future.

As said in the preface of the first book, our particular expertise on signal processing has two main roots: research and teaching. I belong to the Faculty of Physics, University Complutense of Madrid, Spain. During our experimental research on autonomous vehicles, maritime drones, satellite control, etc., we practiced main methods of digital signal processing, for the use of a variety of sensors and for prediction of vehicle motions. From years ago, I teach Signal Processing in a Master of Biomedical Physics, and a Master on New technologies.

The style of the programs included in the book is purposively simple enough. The reader is invited to typeset the programs included in the book, for it would help for catching coding details. Anyway, all programs are available from the book web page: <http://www.dacya.ucm.es/giron/SPBook2/Programs>.

A lot of different materials have been used to erect this book: articles, blogs, codes, experimentation. I tried to cite with adequate references all the pieces that have been useful. If someone has been forgotten, please contact me. Most of the references cited in the text are available from Internet. We have to express our gratitude to the public information available in this way.

Please, send feedback and suggestions for further improvement and support.

Acknowledgments

Thanks to my University, my colleagues and my students. Since this and the other book required a lot of time taken from nights, weekends and holidays, I have to sincerely express my gratitude to my family.

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