Digital Communications and Signal Processing

An Introduction using Octave or Matlab

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Preface

The information age brought new possibilities to improve the learning process, which can complement the traditional lectures and homeworks. With a clear impact in engineering, it is the era in which ITU and other standardization bodies opened access to many of their documents and there are several interesting open source and open hardware projects to help learning through practice. Hence, this book suggests several practical applications for which open source tools (Octave, GNU Radio, GSM projects, etc.) and low cost hardware (USRP, DVB-T dongle, HackRF peripherals, etc.) are key ingredients.

Current communication systems heavily rely on digital signal processing (DSP) and this motivated the effort to present both. This way the book can benefit from using the same nomenclature for both DSP and communications. But there is a well-known exploration versus exploitation tradeoff when defining the contents of a book, especially given that DSP and digital communications are broad areas. In fact, when I teach them, I feel like the guide of a group of tourists with seven days to visit Europe and low budget. This book is the result of my belief that, in spite of being impossible to visit all nice places, it is realistic to learn the basics of two very important engineering subjects and have fun along the process, especially by using resources of interesting open projects.

Because there are so many good and comprehensive textbooks in the subject, I took the route of leaving out topics that are often part of classical courses in favor of including topics that I observe being required when building modern systems such as software defined radios. The choices were biased by my experience in research and development projects with companies such as Ericsson, Brasilsat and Comunix, which substantially influenced my teaching. Hence, the book aims at self-taught readers with a bias towards practice. It does not claim to be a textbook or the ideal reading for those preparing for exams.

This book benefits from free and open source. Accordingly, software developed for the book was made available at the book web site `http://www.aldebaro.ufpa.br`. Even the figures can be reproduced by the reader with the provided source code. Both Mathwork's Matlab and Octave are capable of running most of the code. Matlab's object-oriented programming (OOP) and specific toolboxes that hide important details were avoided. The intention is to motivate the reader to understand and develop his/her own software, not to become familiar with a library or GUI. This strategy also allowed to make most of the code compliant with both Octave and Matlab. The scripts that run only on one of them were organized in specific directories.

Because URLs significantly change over time, instead of listing them in this printed copy, all references identified by [url], such as [urlFMitu] (a unique identifier following the prefix *url*), are organized (and kept updated) at the book web site.

I adopted a self publishing strategy that allows the whole book to be printed in full color with a price close to the printing cost. On the other hand, I performed several tasks that are typically taken care of by a specialized publisher.[1] It was not possible to have a professional proofreader reviewing the text and I apologize for any grammar error.

In 2008, the State Government of Pará, via its research agency, FAPESPA, sponsored my first book and got me started in this activity. I acknowledge here not only this support but all the work that the State Government did at that point in favor of science and technology in Pará, a Brazilian state surrounded by the magnificent Amazon, known for the world's largest tropical rain forest and river basin. The cover[2] of this book depicts this region and its needs for information and communications technologies, to move its economy from primary exploration of natural resources and establish new and green industries.

The current book was finalized at the University of California, San Diego (UCSD), during a sabbatical leave from the Federal University of Para (UFPA), Brazil, sponsored by the CAPES Foundation. Ten years after my Ph.D. graduation, I found myself again very grateful to my always advisor, Professor Alon Orlitsky, for hosting my stay as a visiting scholar at UCSD.[3]

I also acknowledge my students and colleagues at UFPA, researchers at Ericsson and Brasilsat, friends and family for their support. The book is dedicated to my parents, Aldebaro and Regina. Now that my spouse and I try to raise three kids, I better understand the wonderful parents I have. Their wisdom still amazes me when I recollect teachings and arguments. My father accomplished so many amazing things in life, some of strong impact to those living in Pará, and still managed to make his kids proud by winning sport matches (soccer, table tennis, etc.), coaching us, being our math teacher, our friend, etc., while my mother has always unconditionally supported me, with love so intense that it is visible. In the context, an example of her important presence is that when I was loosing interest for engineering, she gave me my first computer, which led me to ask "-How does this work?" and ended up defining my career. And to share my gratitude to God for letting me enjoy writing this book, I use a quote from St. Paul's 2nd Letter to the Corinthians: "Not that we are sufficient of ourselves to think any thing as of ourselves; but our sufficiency is of God".

[1] Regarding Latex typesetting, I was lucky to count with the expertise of Martin Sievers [urlFMlat].
[2] The book cover art is by Bernardo Magalhães with Libra Design [urlFMlib].
[3] I acknowledge the wonderful support from UCSD library staff, especially Ms. Deborah Kegel.