Book Review

Sound Analysis and Synthesis with R

Jérôme Sueur

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This just published and timely book on 'Sound Analysis and Synthesis with R' fills an important space in the bioacoustics research field, inspired by the needs of non-expert acousticians to better understand sound theory and signal processing. While the number of bioacoustic research publications has soared in the last four decades, many obstacles of physical guidance have prevented the adoption of the rigorous process of sound analysis. The author of this book, Dr. Jerome Sueur, is a restless scholar of insect bioacoustics, a pioneering researcher in ecoacoustics, and in monitoring and assessing biodiversity with sound. The book covers these aspects and bridges many gaps in knowledge and uncertainties that we as bioacousticians always experience.

The author starts with a catchy preface, sharing personal anecdotes, expectations, and concerns, which drove his motivation to learn R and write the book. The book is of unique relevance in the field as it is built upon and supported by relevant published articles and existing R packages for sound analysis; it does not go into the fine details of the mathematics of sound theory, as other acoustic books for biologists (e.g. Fletcher 1992). It is intended for students and researchers interested in bioacoustics and ecoacoustics and is comprised of 17 chapters and 88 subchapters or sections. These are effectively summarised in the Table of Contents, and easy to navigate in the digital version. The fundamental goal of a science book is to share information, but an important component of such goal is also to incorporate texts that capture the reader's attention without being arduous to read: this book clearly does both. The definition of concepts and acoustic parameters (e.g. overtones, harmonics, fundamental and dominant frequency) is outstanding, a salient feature that guides the reader to use them appropriately.

Chapter 2 is a brief, but substantial, introduction to sound theory. It starts with an enjoyable section on the definition of sound, and I particularly liked the philosophical debate of a 'Dangerous tree'. I would have loved more discussion on this topic, however I appreciate the fact that such discussions were not the purpose of the book. Illustrations in this chapter are great and necessary for someone who is not an expert in the field. Several acoustic parameters (amplitude, frequency, duration, phase, etc) are well explained with equations and figures. Something that most people seem to find hard to digest is the meaning of phase spectrum; i.e., how the phase of a complex signal varies with frequency. Although the book does not elaborate on that specific topic, there is a thoughtful inspiring aesthetic and descriptive wonderment regarding the concept of comparing the phase of a measured signal against a reference signal of similar frequency. This chapter ends with a substantial explanation of recording, digitization, and potential problems of under sampling, (i.e., aliasing). In summary, this chapter provides a solid introduction to the physics of sound for beginners. Not many books on bioacoustics include such information in such a palatable form.

Chapter 3 introduces R as a free opensource object-oriented language. The author begins with an easily followed practical introduction to working directories and basic functions that reveals the operating logic of the program. This chapter is accompanied by tables containing R objects, operators, and arithmetic functions, and a very useful appendix table at book's end listing all functions used. Not being an R expert (I use Matlab for sound analysis) and with R installed in my Apple computer, I closely followed this chapter after section *3.3. Do you speak R* and had a smooth experience understanding the logic of the program. This made life easy when I read chapters 4-10 and started to play with sound analysis and synthesis (my field), and all the R acoustic packages. I particularly liked chapter 10 because it described many impressive plotting functions for peak and harmonic series identification, frequency analysis, etc. This chapter also includes functions and examples for measuring spectral purity, for example the calculation of the quality factor Q of a signal, a valuable tool in animal bioacoustics. Q is a useful parameter to measure tonality, however it is limited by a symmetric spectrum. Chapter 10 addresses other useful solutions for measuring spectral purity in complex signals, for example entropy, which I have used myself following early published research of the author. Chapter 13 condenses various forms of energy tracking, and I find the options to detect and measure instantaneous frequency by Hilbert transform or by Zero-Crossing very useful. These are very necessary tools for measuring frequency modulation in sinusoids and produce better resolution than a routine spectrographic analysis. Finally, chapters 16 and 17 offer an overview of ecoacoustics and the indices to measure abundance, richness, and also to measure dissimilarities between sounds from various forms and parameters, with algorithms to visualise results as cluster or ordination analyses.

This is a stand-alone, foundational work synthesizing a large amount of research on bioacoustics, signal processing, and signal synthesis techniques. It provides a powerful tool which could be broadly used not only by bioacousticians but also by researchers in related fields, for instance human acoustics, music perception, etc. Future editions of this book will be welcomed as sound science, analytical techniques advance, and random-access memory problems are addressed. Any scholar performing work on acoustics, particularly students and diverse researchers

interested in exploring animal communication by sound and vibration, will enjoy this book. I am pleased to endorse it with a 4.8/5 star rating, and should finish by saying that this book constitutes a good entry level and it is highly recommended for library collections.

References

Fletcher NH (1992) Acoustic systems in biology. Oxford University Press, Oxford.