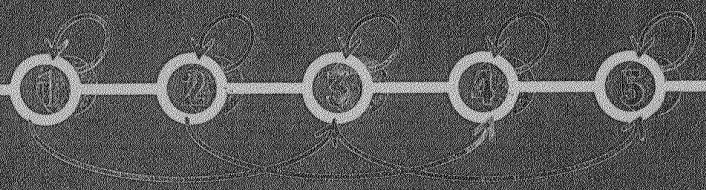
DISCRETE-TIME PROCESSING OF SPEECH SIGNALS



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CHAPTER 1

Propaedeutic

Read.Me: *If you are someone who never reads Chapter 1, please at least read Sections 1.0.2 and 1.0.3 before proceeding*!

1.0 Preamble

1.0.1 The Purpose of Chapter 1

If the reader learns nothing more from this book, it is a safe bet that he or she will learn a new word. A *propaedeutic*[1] is a "preliminary body of knowledge and rules necessary for the study of some art or science" (Barnhart, 1964). This chapter is just that—a propaedeutic for the study of speech processing focusing primarily on two broad areas, digital signal processing (DSP) and stochastic processes, and also on some necessary topics from the fields of statistical pattern recognition and information theory.

The reader of this book is assumed to have a sound background in the first two of these areas, typical of an entry level graduate course in each field. It is not our purpose to comprehensively teach DSP and random processes, and the brief presentation here is not intended to provide an adequate background. There are many fine textbooks to which the reader might refer to review and reinforce prerequisite topics for these subjects. We list a considerable number of widely used books in Appendices 1.A and 1.B.

What, then, is the point of our propaedeutic? The remainder of this chapter is divided into four main sections plus one small section, and the tutorial goals are somewhat different in each. Let us first consider the two main sections on DSP and stochastic processes. In the authors' experience, the speech processing student is somewhat more comfortable with "deterministic" DSP topics than with random processes. What we will do in Section 1.1, which focuses on DSP, therefore, is highlight some of the key concepts which will play central roles in our speech processing work. Where the material seems unfamiliar, the reader is urged to seek help in

[1]Pronounced "prō′-pa-doo′-tic."

one or more of the DSP textbooks cited in Appendix 1.A. Our main objective is to briefly outline the essential DSP topics with a particular interest defining notation that will be used consistently throughout the book. A second objective is to cover a few subtler concepts that will be important in this book, and that might have been missed in the reader's first exposure to DSP.

The goals of Section 1.2 on random processes are somewhat different. We will introduce some fundamental concepts with a bit more formality, uniformity, and detail than the DSP material. This treatment might at first seem unnecessarily detailed for a textbook on speech processing. We do so, however, for several reasons. First, a clear understanding of stochastic process concepts, which are so essential in speech processing, depends strongly on an understanding of the basic probability formalisms. Second, many engineering courses rely heavily on stochastic processes and not so much on the underlying probability concepts, so that the probability concepts become "rusty." Emerging technologies in speech processing depend on the basic probability theory and some review of these ideas could prove useful. Third, it is true that the mastery of any subject requires several "passes" through the material, but engineers often find this especially true of the field of probability and random processes.

The third and fourth major divisions of this chapter, Sections 1.3 and 1.4, treat a few topics which are used in the vast fields of statistical pattern recognition and information theory. In fact, we have included some topics in Section 1.3 which are perhaps more general than "pattern recognition" methods, but the rubric will suffice. These sections are concerned with basic mathematical tools which will be used frequently, and in diverse ways in our study, beginning in Part IV of the book. There is no assumption that the reader has formal coursework in these topics beyond the normal acquaintance with them that would ordinarily be derived from an engineering education. Therefore, the goal of these sections is to give an adequate description of a few important topics which will be critical to our speech work.

Finally, Section 1.5 briefly reviews the essence and notation of phasors and steady-state analysis of systems described by differential equations. A firm grasp of this material will be necessary in our early work on analog acoustic modeling of the speech production system in Chapter 3.

As indicated above, the need for the subjects in Sections 1.3–1.5 is not immediate, so the reader might wish to scan over these sections, then return to them as needed. More guidance on reading strategy follows.

1.0.2 Please Read This Note on Notation

The principal tool of engineering is applied mathematics. The language of mathematics is abstract symbolism. This book is written with a conviction that careful and consistent notation is a sign of clear under-

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