

# MEMORY AND CORRELATION

## 2.1 INTRODUCTION

This chapter introduces the intimately related concepts of memory in physical systems and correlation in signals. The concept of *memory* in a physical system reflects the degree to which the present behavior (or output) is influenced by (or “remembers”) past behaviors (inputs or outputs). Many physical systems exhibit memory. For example, if a pendulum is held at an angle to the vertical then released, it will oscillate transiently instead of dropping immediately to its rest position. The transient behavior reflects some memory of its initial potential energy. Memory in a physical system is an expression of the inability of the system to dissipate or redistribute its energy instantaneously. If the system is well understood, often one can relate this memory to specific parameters of the physical system. Thus there is potentially a great benefit from deriving a quantitative measure of memory based on observations of the output signal of a system, because such a measure might provide quantitative information about the parameters of an unknown system. Furthermore, as will be evident in Chapter 3, the input–output properties of a linear system can be almost completely described in terms of the memory properties of the system. On the other hand, virtually all methods of linear signal processing can be derived from the concept of correlation.

*Correlation* in a signal relates to the degree to which the signal at the present time reflects its values in the past. The similarity between these heuristic definitions of memory and correlation suggest the possibility of strong linkages between correlation properties of a signal and memory properties of the system from which the signal arises. Indeed, analysis of correlation in signals from physical systems provides a quantitative measure of memory, from which important properties of a physical system can be inferred.

This chapter begins by defining some basic properties of signal transformations and continues with an example and a discussion of memory in physical systems. Later the concept of correlation is defined mathematically and correlation analyses of several examples are presented. In this chapter the discussion will address deter-