# Chapter 1
# Digital Technology:
## Capabilities and Limitations

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## ABSTRACT

*Digital technologies are at the heart of all modern communication and information systems. The technologies have evolved from expensive component devices to current inexpensive systems used by everyone. This chapter examines digital technology in terms of its capabilities and limitations. It attempts to answer the following questions: What is digital technology? How does digital technology represent characters, symbols, and language? How does digital technology represent sound, images, and video? How does digital technology store and transmit these types of information? Finally, this chapter explores limitations of digital technology.*

## INTRODUCTION

The first purpose of this chapter is to introduce the fundamental ideas about how information is represented when using digital technologies. The second purpose is to identify the capabilities and limitations of these representations and to suggest avenues for future research and development as well as implications for a manager working with, and dependent on, digital technologies.

Digital technologies have become the core building block of all modern information and communication systems. Digital computer systems use databases and processing algorithms to store and deliver digital information on a vast array of applications. Networks, most notably the Internet, interconnect these computer systems across the world enabling the exchange of data and information. More importantly, perhaps, these networks allow applications to be created that are resident on multiple computers in the network facilitating distributed applications with processing power of enormous magnitude.

The importance of digital technologies suggests that an understanding of what makes a system digital is critical to assessing its capabilities and

DOI: 10.4018/978-1-61692-877-3.ch001

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limitations. The natural world is not digital. Yet much of what modern consumers and businesses do to conduct the activities of daily commerce is based on digital technologies. One purpose of this chapter is to show how the digital world represents the natural world.

To explore how information is represented in digital systems, we start with basic idea how information arises in natural systems. We then look at the evolution of symbols, alphabets, and other representations of information. The advent of digital representation of information starts with binary digits and the organization of these digits to represent numeric values, alphabets, and symbols. The basic ideas of such representations are outlined and specific standards are then presented.

We next examine how images can also be represented using combinations of binary digits. The evolution of the standards for representations of images is presented ending with a discussion of modern standards.

The objective of this chapter is paint a picture of how binary digits are used to represent information, whether the information is in the form of language or in the form of images. At the same time, the goal is to show how these representations facilitate and limit what modern processing systems do.

## REPRESENTING INFORMATION

Each of us gets information through the use of our five basic senses: hearing, sight, smell, touch, and taste. First-hand information comes from what each of us personally experiences via these basic senses. Each of us interacts with humans via these same senses, which allows us to obtain information from others. We do this using images and language. Language can be spoken or it may be written alphabetic representations of the words used in the language.

Memory allows each of us to retain information obtained from experience and from others. Memory is part of the human experience. However, memory also exists when pictures, symbols and alphabetic representations are placed where they persist through time. For example, pictures can be draw in the sand or painted on a canvas. Memory allows us to retrieve information that relates to events that have occurred the past.

In this chapter we will focus primarily on information represented by language and images. This means we are primarily interested in the senses of sight and hearing. As we shall see, the use of digital representations is almost entirely limited to these two senses.

In the following sections we start with an examination of natural systems and representations of information in these systems. We then examine the nature of digital systems and representations. Then we look at how these ideas are applied to represent sound, images, and languages.

### Analog vs. Digital

The starting point for thinking about what digital means is to explore the contrasts between representations that are analog and those that are digital. Analog representations are measures that are natural and continuous. Digital representations are measures that are invented and discrete.

Analog measures vary over a span of characteristics where the values are continuous. For example, consider a glass containing some amount of water. How much water is in the glass? It may be full or it may be empty. Or it may be somewhere between. The possible states ranging between empty and full are infinite in number. The amount of water in the glass is an analog measure.

Digital measures are representations with discrete values. Some digital representations are exact. For example, the number of coins in a purse would be an exact measure. However, other digital representations are approximations. For example water in a one-cup measuring cup with a graduated scale showing popular fractions would be both analog, the amount of water, and

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