CHAPTER

1

AN OVERVIEW OF DIGITAL SIGNAL AND IMAGE PROCESSING

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1.1 INTRODUCTION

Signal processing is the critical enabling technology for our smartphones and wearable devices, as well as the latest healthcare technologies, digital cameras, and digital assistants such as Amazon Echo and Google Home. The various applications of signal processing can be seen in control systems, biomedical engineering, voice recognition systems, and radar signal processing in addition to telecommunications. Since decades ago, signal processing has been a branch of electrical engineering that employs mathematical calculations to analyse, transform and synthesize signals like sound, images, and scientific measurements. It entails altering data so that it can be observed, interpreted, or transformed into a different signal type.

Digital and analog are diametrically opposed. Like computers, signal processing has become synonymous with Digital Signal Processing (DSP). Although analog signal processing and analog computers exist, their applications are limited compared to their digital counterparts.

Nevertheless, most signals in our physical environment are analog. Analog signals must be converted to digital before being processed, and then converted back to analog once the processing is complete. Sensors collect and display physical quantities that change over time, such as speech, temperature, pressure, and location, as a continuous analog signal (Oppenheim & Schafer, 1975). Mathematically modifying the numerical values of a digital signal improves its quality and effects. You can also transform into a different domain, such as converting a sound wave to an MP3 file.

Digital Signal Processing (DSP) heavily relies on mathematics to perform transforms. We may hear z-transforms, laplace transforms, cosine transforms, and fourier transforms when performing signal processing. Transforms are used in their most basic form when working with time-varying signals, also known as one-dimensional signals (Rabiner & Gold, 1975).

Image, on the other hand, are two-dimensional signals that communicate information through colour and light intensity. As a result, photo enhancement, object recognition, and forgery detection are all part of digital image processing, which is a subset of digital signal processing. In video processing, we can go one step beyond still images by analysing multiple video images in tasks like video content analysis and action recognition. To summarize, the higher the dimension, the more computationally complex the transforms and analyses will be.

There are a handful of different "parts" that make up a DSP system, as depicted in Figure 1.1.

(1) Sampling: Analog signals are transformed to digital using Analog-to-Digital Converters (ADCs).

(2) Processing: Digital signal processing can be performed on a regular computer, a specialized digital signal processor or custom hardware.

(3) Reconstruction: Digital signals are converted back to analogy for consumption using Digital-to-Analog Converters (DACs).

Processing can take the form of real-time signal processing, digital transmission over communication channels, or storage for subsequent analog conversion.

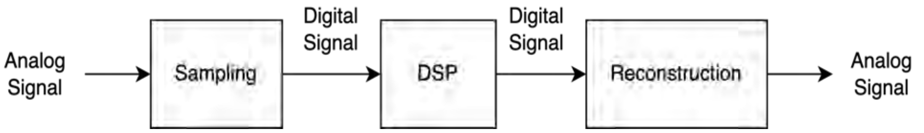

Figure 1.1 Basic digital signal processing system

There are various advantages of processing signals in digital form.

(1) Efficiency: Signal processing techniques can improve transmission efficiency, storage efficiency and subjective quality, as well as to highlight or hide important components in a measured signal.

(2) Information: Information can be used to enhance or improve desired aspects of a signal or even to reduce undesirable aspects.

(3) Adaptation: Information is adaptively processed by DSP. This concept is critical in a dynamic application like sound and speech, particularly in industrial settings.

(4) Flexibility: DSP creates flexibility. Changes, updates, customizations, and many other features are available with the implementation of DSP systems.

(5) Security: Digital information can be encrypted, encoded, and compressed mathematically.

(6) Cost: DSP chips are relatively cheap and easily mass-produced. Digital storage and transmission are also cheap.

There are a few disadvantages to digital signal processing as well:

(1) Information is lost as a result of sampling. This can be reduced by employing more bits or a higher sample rate, but at a cost. As a result, the number of bits per sample and sampling rate are always a compromise between efficiency and accuracy.

(2) High-resolution ADCs and DACs can be costly.

(3) Real-time digital processing is not always possible.

Although signal processing in analog form is simple and uncomplicated, it has quality and cost restrictions. We cannot record the