INTRODUCTION

We are living in an age of information technology. Most of this technology is based on the theory of digital signal processing (DSP) and implementation of the theory by devices embedded in what are known as digital signal processors (DSPs). Digital signal processing is used in several areas, including the following:

1. Telecommunications. Wireless or mobile phones are rapidly replacing wired (landline) telephones, both of which are connected to a large-scale telecommunications network. They are used for voice communication as well as data communications. So also are the computers connected to a different network that is used for data and information processing. Computers are used to generate, transmit, and receive an enormous amount of information through the Internet and will be used more extensively over the same network, in the coming years for voice communications also. This technology is known as voice over Internet protocol (VoIP) or Internet telephony. The new technologies being used in the abovementioned applications are known by such terms as CDMA, TDMA,1 spread spectrum, echo cancellation, channel coding, adaptive equalization, ADPCM coding, and data encryption and decryption.

2. Speech Processing. The quality of speech transmission in real time over telecommunications networks from wired (landline) telephones or wireless (cellular) telephones is very high. Speech recognition, speech synthesis, speaker verification, speech enhancement, text-to-speech translation, and speech-to-text dictation are some of the other applications of speech processing.

3. Consumer Electronics. We have already mentioned cellular or mobile phones. Then we have HDTV, digital cameras, digital phones, answering machines, fax and modems, music synthesizers, recording and mixing of music signals to produce CD and DVDs. Surround-sound

entertainment systems including CD and DVD players, laser printers, copying machines, and scanners are found in many homes. But the TV set, PC, telephones, CD-DVD players, and scanners are present in our homes as separate systems.

4. Biomedical Systems. The variety of machines used in hospitals and biomedical applications is staggering. Included are X-ray machines, MRI, PET scanning, bone scanning, CT scanning, ultrasound imaging, fetal monitoring, patient monitoring, and ECG and EEC mapping. Another example of advanced digital signal processing is found in hearing aids and cardiac pacemakers.

5. Image Processing. Image enhancement, image restoration, image understanding, computer vision, radar and sonar processing, geophysical and seismic data processing, remote sensing, and weather monitoring are some of the applications of image processing. Reconstruction of two-dimensional (2D) images from several pictures taken at different angles and three-dimensional (3D) images from several contiguous slices has been used in many applications.

6. Military Electronics. The applications of digital signal processing in military and defense electronics systems use very advanced techniques. Some of the applications are GPS and navigation, radar and sonar image processing, detection and tracking of targets, missile guidance, secure communications, jamming and countermeasures, remote control of surveillance aircraft, and electronic warfare.

7. Aerospace and Automotive Electronics. Applications include control of aircraft and automotive engines, monitoring and control of flying performance of aircraft, navigation and communications, vibration analysis and antiskid control of cars, control of brakes in aircrafts, control of suspension, and riding comfort of cars.

8. Industrial Applications. Numerical control, robotics, control of engines and motors, manufacturing automation, security access, and videoconferencing are a few of the industrial applications.

A signal defines the variation of some physical quantity as a function of one or more independent variables, and this variation contains information that is of interest to us. For example, a continuous-time signal that is periodic contains the values of its fundamental frequency and the harmonics contained in it, as well as the amplitudes and phase angles of the individual harmonics. The purpose of signal processing is to modify the given signal such that the quality of information is improved in some well-defined meaning. For example, in mixing consoles for recording music, the frequency responses of different filters are adjusted so that the overall quality of the audio signal (music) offers as high fidelity as possible. It is the functional relationship between the function and the independent variable that allows us to derive methods for modeling the signals and find the output of the systems when they are excited by the input signals. This also leads us to develop methods for designing these systems such that the information contained in the input signals is improved.

We define a continuous-time signal as a function of an independent variable that is continuous. A one-dimensional continuous-time signal $f(t)$ is expressed as a function of time that varies continuously from $-\infty$ to ∞. But it may be a function of other variables such as temperature, pressure, or elevation; yet we will denote them as continuous-time signals, in which time is continuous but the signal may have discontinuities at some values of time. The signal may be a real- or complex-valued function of time. We can also define a continuous-time signal as a mapping of the set of all values of time to a set of corresponding values of the functions that are subject to certain properties. Since the function is well defined for all values of time in $-\infty$ to ∞, it is differentiable at all values of the independent variable t (except perhaps at a finite number of values). Two examples of continuous-time functions are shown in Figure 1.

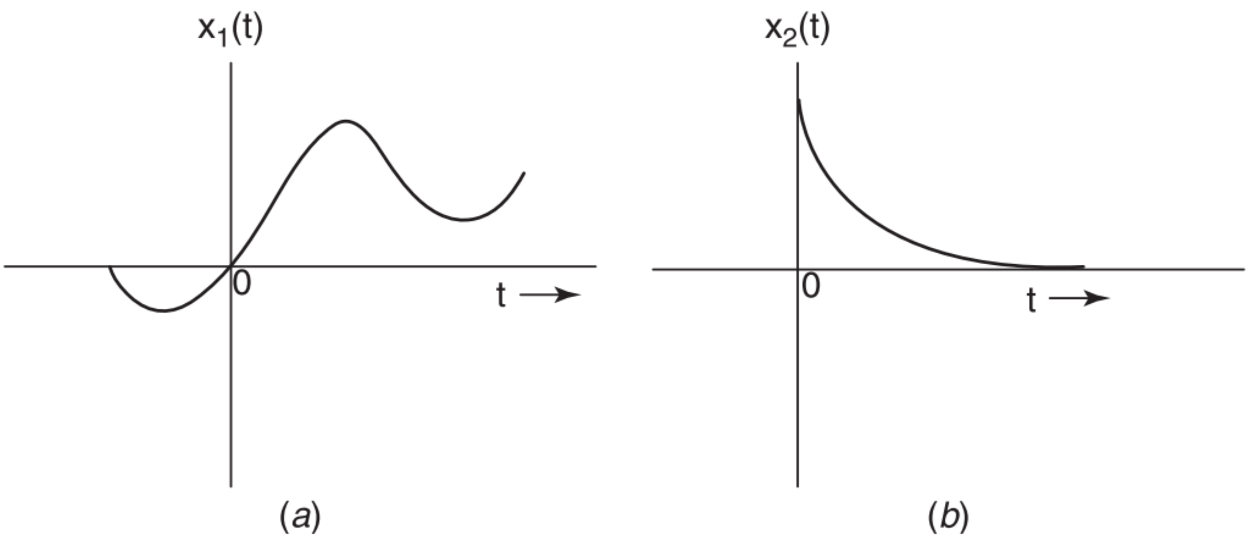

Figure 1: Two samples of continuous-time signals

A discrete-time signal is a function that is defined only at discrete instants of time and undefined at all other values of time. Although a discrete-time function consider only a function defined at equal intervals of time and defined at $t = nT$, may be defined at arbitrary values of time in the interval $-\infty$ to ∞, we will where T is a fixed interval in seconds known as the sampling period and n is an integer variable defined over $-\infty$ to ∞. If we choose to sample $f(t)$ at numbers. Since T is fixed, $f(nT)$ is a function of only the integer variable n and equal intervals of T seconds, we generate $f(nT) = f(t)|_{t=nT}$ as a sequence of hence can be considered as a function of n or expressed as $f(n)$. The continuous-time function $f(t)$ and the discrete-time function $f(n)$ are plotted in Figure 2.

We will denote a discrete-time (DT) function as a DT sequence, DT signal, or a DT series. So a DT function is a mapping of a set of all integers to a set of values of the functions that may be real-valued or complex-valued. Values of both $f(t)$ and $f(n)$ are assumed to be continuous, taking any value in a continuous range; hence can have a value even with an infinite number of digits, for example, $f(3) = 0.4\sqrt{2}$ in Figure 2.

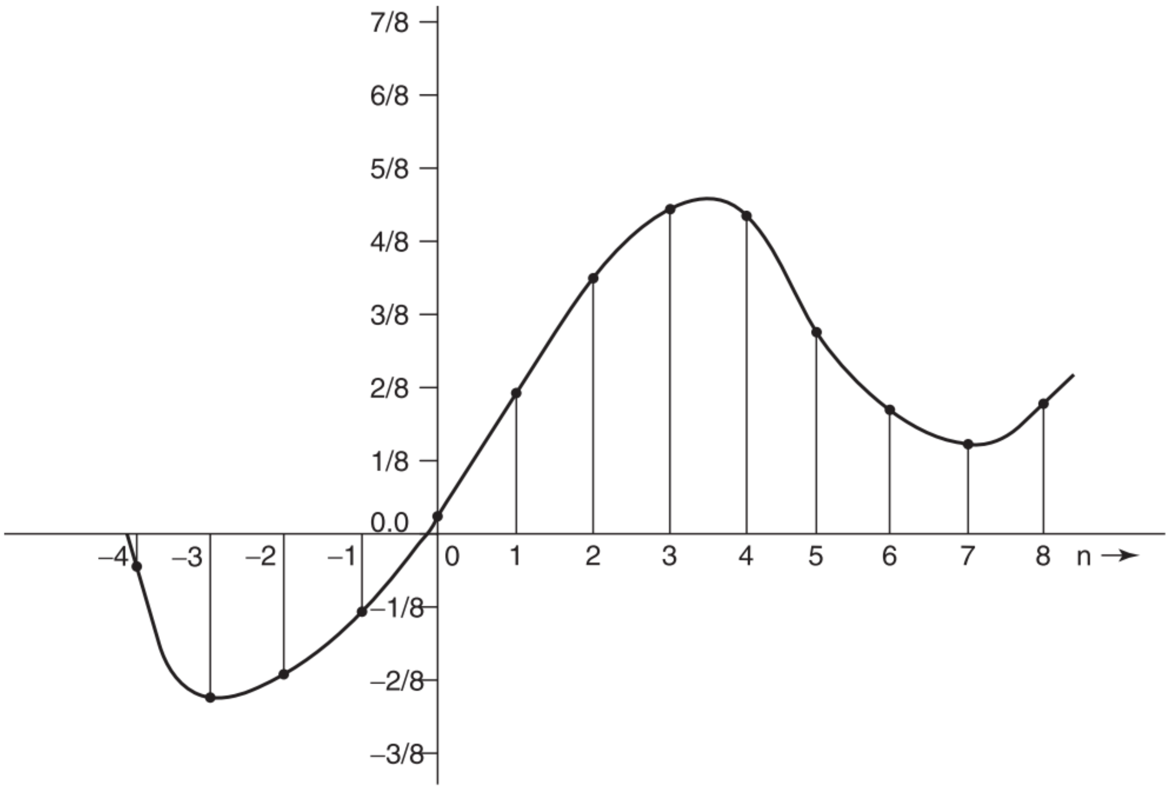

Figure 2: The continuous-time function $f(t)$ and the discrete-time function $f(n)$.

A zero-order hold (ZOH) circuit is used to sample a continuous signal f(t) with a sampling period T and hold the sampled values for one period before the next sampling takes place. The DT signal so generated by the ZOH is shown in Figure 2, in which the value of the sample value during each period of sampling is a constant; the sample can assume any continuous value. The signals of this type are known as sampled-data signals,

References and further read:

INTRODUCTION TO DIGITAL SIGNAL PROCESSING AND FILTER DESIGN, Shenoi, B. A.