Signals Everywhere

Key Concepts

1) Signals contain information.

2) Signal processing pertains to the representation and manipulation of the information in signals.

3) The range of applications for signal processing is almost endless.

4) A common set of well-developed principles and concepts are the basis for all applications of signal processing.

5) Digital signal processing involves converting analog, or continuous-valued, signals to a numerical representation for manipulation in a computer.

6) Signal processing applications have grown significantly as computing capabilities have increased in the past 30 years.

Transcript

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Introduction

Signals and signal processing are pervasive in our world and enable many of our everyday experiences.

Signals convey information. Examples include the sound waves we hear when listening to music or a conversation, the air temperature, the electrical activity of the heart recorded by placing electrodes on the chest, the price history of a company's stock, and the sequences of images making up a movie.

The list of what constitutes a signal is almost endless.

Signal processing involves the representation and manipulation of the information contained in signals.

Humans have been processing signals since our beginning – the human brain has an amazing ability to process sensory signals to perform complex tasks such as recognizing food, locating the face of a friend in a crowd, and identifying hazards on the road while driving a vehicle.

The use of computers for processing signals began shortly after the invention of the computer and has exploded in the past 25 years.

Signal processing is now a critical part of consumer products like televisions, cell phones, noise cancelling headphones, automobiles, and global positioning systems. Signal processing is also an essential component of medical and military devices, remote sensing for weather forecasting and astronomy, transportation systems like air traffic control, and financial engineering. The extent of signal processing applications is as widespread as signals themselves.

Although the range of applications for signal processing is incredibly diverse, a common set of well-developed principles and concepts lies at the core of all signal-processing applications.

Digital signal processing

The widespread advent of signal processing into all areas of our lives has been fueled by the development of low-cost, electronic components for converting signals from analog to digital format (A/D converters) and back to analog format (D/A converters), and powerful digital computer chips for manipulating signals. Theoretical developments in the field of signal processing have led to increasingly sophisticated ways of using computers to manipulate signals.

The physical world in which we live is inherently analog. Physical quantities such as temperature, sound pressure waves, positions of objects, electrical voltage and current, and visual images are defined on a continuous scale. Their

values exist at all points in time or space and can vary continuously, like the hands on an analog clock.

Converting physical quantities to a digital format involves capturing values of the analog signal at samples in time with a limited precision. This is similar to the manner in which a digital clock represents time with a precision of minutes or seconds, in contrast to the continuous positions of the hands on an analog clock. This digital format represents the signal using a sequence of numbers that can be easily manipulated, or "processed" using a computer.

A brief history

Prior to the 1950s, processing of signals was performed exclusively in the analog realm by electrical circuits and mechanical devices.

One of the first applications of computer-based signal processing was oil and gas exploration. Seismic signals are relatively low frequency and require relatively few samples per second. Furthermore, recorded seismic data could be post processed for days or weeks if necessary. These attributes made digital signal processing practical in spite of the relatively limited computing capabilities available at that time.

A development with enormous impact on the growth of signal processing was the disclosure by Cooley and Tukey in 1965 of a fast algorithm for performing Fourier analysis. The

fast Fourier transform (FFT) algorithm reduced computation cost by orders of magnitude and permitted increasingly sophisticated signal processing algorithms to be implemented on existing computers.

The year 1980 brought the release of compact disc (CD) audio, one of the first consumer applications of signal processing. CDs store music on optical disks in digital format using 44,100 samples per second, with each sample representing one of 2^{16} or 65,536 possible sound amplitude levels. The CD player converts the string of numbers representing the music back to an analog form for playback over loudspeakers.

The 1980s also saw the development of digital signal processing chip sets, special purpose computing devices designed to perform typical signal processing operations at high speed.

Medical, military, industrial, and consumer applications of signal processing have proliferated over the past 30 years as computing capabilities have grown and costs have shrunk.

Looking forward

Signal processing will continue to play an essential role in medicine, entertainment and communication technology. It will be a key contributor to improving our understanding of the world in which we live, our productivity, and our experience.

Signal processing has always thrived on new applications. While it is difficult to predict exact path the future of this field will follow, there is abundant indication that it will be incredibly bright and full of opportunities.

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