Presenting Signal Processing techniques

-R. Naga Leela Krishna

Audio signals are the representation for sound waves, whether it is an analog or digital source, being computed and generated to be utilized as data for application.

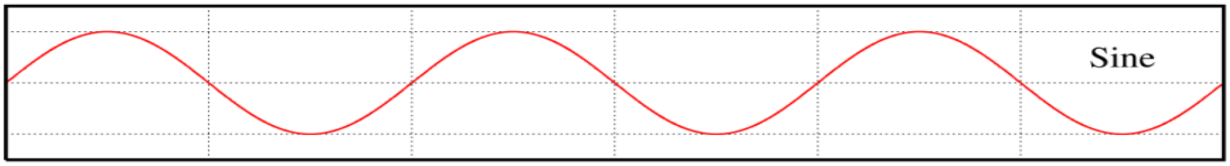
It is actually a subtopic of Digital Signal Processing, which is the main topic of translating data into a computer form to be used, where data can vary from speech, imaging, telecommunication, seismology, biomedical engineering, etc.

Examples in applying Audio Signal Processing:

- storage
- data compression
- speech processing
- transmission
- noise cancellation
- acoustic fingerprinting
- enhancement (equalization, filtering, level compression, echo and reverb removal or addition, etc.)

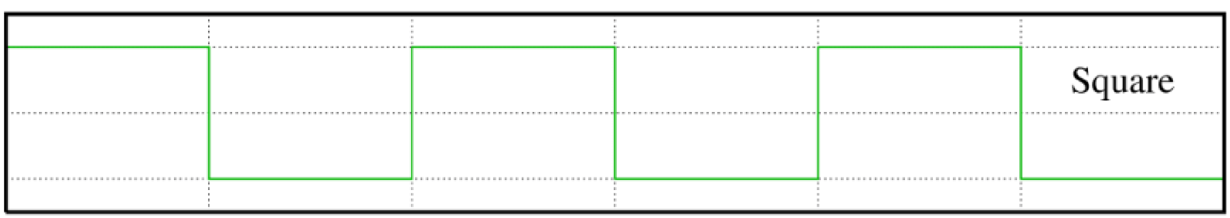
Audo signals are the representation of sound. There are two different types of signals: Analog and Digital Signals.

- Analog is represented with a sign wave, described with Period, Amplitude, Phase and Frequency.



With this representation of the data, it can be translated and interpreted as digital data to be processed with the computer now. This is most represented as a sine wave. Analog is like the human voice where you can control your volume, speed, and articulation, etc.

- Digital is represented with a square wave. It carries data in binary form. It's described with bit rate and bit interval.



The square wave is more straight-forward with no curves and slopes. This means that the sound would be cutoff with no steady progression. Digital is like picking a note on an electric guitar immediately (unless you control your volume with the volume knob).

Various applications of signal processing are :

- Speech processing , speech technology
- Image processing

- Medical or biometric Image processing
- Mobile communication, Telecommunication
- SONAR, RADAR
- Voice over IP (VoIP), Automated voice

Techniques for Signal Processing :

Signal processing techniques can be used to improve transmission, storage efficiency and subjective quality and to also emphasize or detect components of interest in a measured signal.

Various signal processing techniques are used for the feature extraction such as Fourier transform, wavelet transform, S-transform, Hilbert transform, Gabor transform and their hybrids.

Fourier Transform : It is one of the most commonly used methods of signal analysis. It is simply a mathematical transformation that changes a signal from a time domain representation to a frequency domain representation thereby allowing one to observe and analyze its frequency content.

This technique has proven to have application in many other unrelated disciplines including the analysis of electromagnetic signals. Fourier's Theorem essentially states that the frequency content of any signal can be described as the sum of a specific set of sine waves.

A time signal can be represented in the Fourier (frequency) domain in three possible ways, namely the Continuous Fourier Transform (CFT), the Fourier Series (FS) and the Discrete Fourier Transform (DFT).

Kalman filtering : It is also known as linear quadratic estimation (LQE), an algorithm that uses a series of measurements observed over time, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more accurate than those based on a single measurement alone, by estimating a joint probability distribution over the variables for each timeframe.

The Kalman filter keeps track of the estimated state of the system and the variance or uncertainty of the estimate. The estimate is updated using a state transition model and measurements.

The Kalman filter has numerous applications in technology. A common application is for guidance, navigation, and control of vehicles, particularly aircraft and spacecraft.

Wavelet transform : It is a tool that cuts up data, functions or operators into different frequency components with a resolution matched to its scale. In signal analysis, the wavelet transform allows to study the time history in terms of its frequency content.

Wavelet transform can extract local spectral and temporal information simultaneously. A practical application of the Wavelet Transform is analyzing ECG signals which contain periodic transient signals of interest.

S-transform (ST) : It is a time-frequency representation known for its local spectral phase properties. A key feature of the S- transform is that it uniquely combines a frequency dependent resolution of the time-frequency space with absolutely referenced local phase in-formation.

It also exhibits a frequency invariant amplitude response, in contrast to the wavelet transform. This manuscript outlines the derivation of the

S-transform and gives a detailed description of the implementation of the algorithms.

S transform has been proven to be able to identify a few types of disturbances, like voltage sag, voltage swell, momentary interruption, and oscillatory transients.

Hilbert–Huang transform (HHT) : It is a new signal processing technique that is applicable for nonstationary and nonlinear signals.

It is a combination of two methodologies [86], namely, empirical mode decomposition (EMD) and Hilbert transform (HT). In the first step, the input signal will be decomposed into different components by using EMD, which are termed as intrinsic mode functions (IMFs). In the second step, the Hilbert spectrum is obtained by performing the HT over the IMFs.

This technique is used to obtain the minimum-phase response from a spectral analysis. It is also used to enhance the time-frequency analysis of microtremor measurements.

Gabor transform (GT) : It is one of the time frequency distribution (TFD) technique and good in distinguishing the harmonic and inter-harmonic signals in power distribution system.

The GT is the windowed Fourier transform and the representation of a signal in a jointly time-frequency domain. The harmonic signals are analyzed and represented in time frequency representation (TFR).

The Gabor transform allows quantitative estimation of the non-stationarity of the electromyographic signal in the low-frequency region with the maxim permissible time–frequency resolution.