

Sound Representation

Key Concepts & Terms

We will be looking at the following concepts:-

- (1) Analogue Data**
- (2) Digital Representation**
- (3) Analogue to Digital Converter**

- (4) Sample**
- (5) Sampling Interval**
- (6) Sample Frequency or Rate**
- (7) Bit Rate**
- (8) File Size**

- (9) Quality**
- (10) Factors affecting the Quality of Sound**
- (11) Factors Affecting File Size**

- (12) How to identify a Sound File through the File Extensions**

CLNandi (Dr)

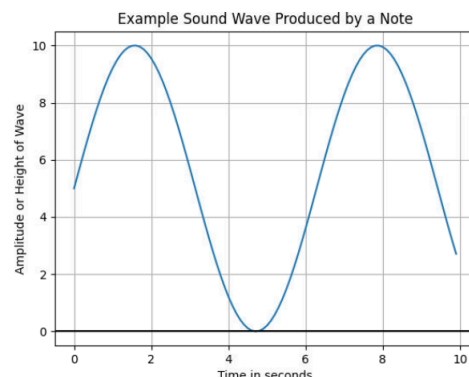
Introduction

(1) Sounds are produced by different sources, these are analogue in nature.

(2) The Source of the sound could be an instrument such as a piano, violin, drum, cello, trumpet or your voice or any number of things.

(3) The Sound Wave is an analogue signal.

(4) An analogue signal is continuous in nature



Analogue Wave

Analogue to Digital Converter

Original Sound Produced is an Analogue Signal

Digital Signal is the type of signal the computer understands

(5) Now, computers represent sound in a different way.

(6) Computers represent sound in a Digital fashion.

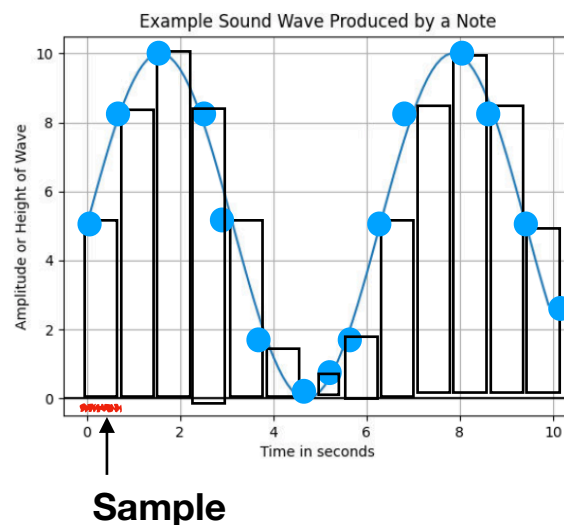
(7) So, the original sound wave which is analogue in its nature must be converted to a digital form in order for the computer to represent it.

(9) This conversion is performed by an analogue to digital converter.

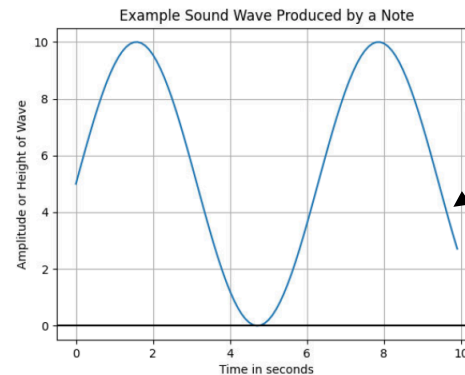
(10) Digital signals are discrete i.e. not continuous

Showing in Detail how Original Analogue Sounds are Converted to A Digital Form

Analogue to Digital Conversion



A Sound Wave Produced by a Note Played on the Piano



Analogue Wave

(1) These Blue dots represent the amplitude of when samples taken

(2) The amplitude (or height) is measured at regular intervals

(3) This is known as sampling and samples are produced.

(4) A sample is a measure of the amplitude at a point in time.

(5) The time gaps between samples are called the sample intervals

(6) This red line represents a sample interval.

(7) The values of the amplitudes are then stored as a series of binary numbers.

(8) Note, that the smaller the sample interval, the more accurately the original sound can be produced.

Samples, Sample frequency & Sample Size

Samples - two aspects to samples Sample Frequency & Sample Size

Sample Frequency (or also called Sample Rate)

This is the number of samples taken per unit of time. i.e in each second.

The unit of sampling frequency is the Hz (Hertz) which is number of samples per second.

Increasing the Sample Frequency results in a better quality of sound,

Sample Size (unit bits/sample)

This is the number of bits associated with a sample (analogous to bit-depth in images)

The Unit of Sample Size is in bits/sample

Increasing the Sample Size results in a better quality of sound.

Samples Frequency (or Rate) * Sample Size = Bit Rate

The Idea of the Quality of a Sound or the idea of Forming an Accurate Representation of the Original Sound

(1) So, you have the original sound.

(2) And when you sample at regular intervals, you want to sample it so that you have an accurate representation of the original sound.

(3) You want a faithful representation of the original sound.

(4) And we use the term 'Quality' we mean how close to the Original Sound is the Digital Representation (how faithful the representation is).

(5) In general, a sampling frequency of around 40,000 times per second (40Khz) is enough to create a reasonable sound reproduction.

If the sampling frequency is lower than that, the human ear hears distortions. A higher sampling rate produces better-quality sound, but after a certain point the extra data is irrelevant as the human ear cannot hear the difference.

Factors Affecting the Quality of the Sound & File Size

(1) By Quality we mean how close to the Original Sound is the Digital Representation.

(2) Increasing the Sample Frequency OR the Sample Size OR the Sampling Interval will result in:-

- (i) Increase of the quality of the sound produced becomes closer to the original sound.**
- (ii) Increase in the file size as there are more samples to store.**

(3) Decreasing the Sample Frequency OR the Sample Size OR the Sampling Interval will result in:-

- (i) Decrease of the quality of the sound as produced becomes less closer to the original sound.**
- (ii) Decrease in the file size as there are fewer samples to store.**

(4) An increased BIT RATE means:-

(i) Increase in the quality,

(ii) Increase in the file size. Note:-

File Size (in number of bits) = Sampling frequency (or rate) * sample size * Time (in sec)

File Size (in number of bits) = Bit Rate * Time (in sec)

Formulas Connected with Sound

From this we get the concept of the Bit Rate which is the number of bits Per second of audio & it is calculated using the following formula:-

Formula 1

Bit Rate = Sampling frequency (or rate) * sample size

Learn all
of these 3
formulas

The Units of Bit Rate = Bits /Second

Formula 2

File Size (in number of bits) = Bit Rate * Time (in sec)

The Units of Sampling Frequency = Number of
Samples Taken /Second

Formula 3

File Size (in number of bits) = Sampling frequency (or rate) * sample size* Time (in sec)

The Units of Sample Size = No of Bits / Sample

Question 1

- (1) Calculate the file size in KiloBytes (KB) of a sound lasting 5 seconds, with a sample frequency of 44,100 Hz and a bit rate of 16 bits per sample.

Hint

File Size (in number of bits) = Sampling frequency (or rate) * sample size * Time (in sec)

Question & Answer 1

- (1) Calculate the file size in KiloBytes (KB) of a sound lasting 5 seconds, with a sample frequency of 44,100 Hz and a bit rate of 16 bits per sample.

Answer

File Size (in number of bits) = Sampling frequency (or rate) * sample size * Time (in sec)

$$= 44,100 * 16 * 5$$

$$= 3,528,000 \text{ Bits}$$

Now, as 8 bits make a byte

$$3,528,000 \text{ Bits} = 3,528,000 / 8 \text{ Bytes}$$

$$= 441,000 \text{ Bytes}$$

$$= \underline{441 \text{ KB}} \text{ (as 1000 Bytes make a KiloBytes)}$$

Question 2

- (1) Calculate the file size in KiloBytes of a sound lasting 10 seconds, with a sample frequency of 8000 Hz and a bit rate of 16 bits per sample.

Hint

File Size (in number of bits) = Sampling frequency (or rate) * sample size * Time (in sec)

Question & Answer 2

- (1) Calculate the file size in KiloBytes of a sound lasting 10 seconds, with a sample frequency of 8000 Hz and a bit rate of 16 bits per sample.

Answer

File Size (in number of bits) = Sampling frequency (or rate) * sample size * Time (in sec)

$$= 8000 * 16 * 10$$

$$= 1,280,000$$

Now, as 8 bits make a byte

$$1,280,000 \text{ Bits} = 1,280,000 / 8 \text{ Bytes}$$

$$= 160,000 \text{ Bytes}$$

$$= \underline{160 \text{ KB}} \quad (\text{as } 1000 \text{ Bytes make a KiloBytes})$$

Question 3

(1) A TV Channel records an interview with a Mr. Gates using a computer and audio recording software. Explain how sampling is used to store audio recordings.

(2) Another interview is recorded with a Mr. Musket. Before this interview, the sampling frequency in the audio software is increased.

Define what is meant by the term sampling frequency.

Question & Answer 3

- (1) A TV Channel records an interview with a Mr. Gates using a computer and audio recording software. Explain how sampling is used to store audio recordings.

Answer

The height (or amplitude) of a waveform is sampled/measured at regular intervals.

This is then converted to binary.

- (2) Another interview is recorded with a Mr. Musket. Before this interview, the sampling frequency in the audio software is increased.

Define what is meant by the term sampling frequency.

Answer

The sampling frequency is the number of samples taken per second.

It is measured in Hertz.

Question 4

Place a 'Yes' by two boxes to show the effects of increasing the sampling frequency.

Scenario	Place a 'Yes' Box if correct
The file size of the digital recording will be smaller	
The file size of the digital recording will be larger	
The quality of playback of the digital recording will be better.	
The quality of playback of the digital recording will be worse.	

Question and Answer 4

Place a 'Yes' by two boxes to show the effects of increasing the sampling frequency.

Scenario	Place a 'Yes' Box if correct
The file size of the digital recording will be smaller	
The file size of the digital recording will be larger	Yes
The quality of playback of the digital recording will be better.	Yes
The quality of playback of the digital recording will be worse.	

Recognising a Sound File - Audio Formats

Popular extensions of sound files are:-

***.MP3**

***.WAV**

That's all for now folks!!

Code which generated the Sound Wave in a Previous Slide

```
import numpy as np
import matplotlib.pyplot as plot

# Get x values of the sine wave
time = np.arange(0, 10, 0.1);

# Amplitude of the sine wave is sine of a variable like time
amplitude = np.sin(time)+1

# Plot a sine wave using time and amplitude obtained for the sine wave
plot.plot(time, amplitude*5)

# Give a title for the sine wave plot
plot.title('Example Sound Wave Produced by a Note')

# Give x axis label for the sine wave plot
plot.xlabel('Time in seconds')

# Give y axis label for the sine wave plot
plot.ylabel('Amplitude or Height of Wave')
plot.grid(True, which='both')
plot.axhline(y=0, color='k')
plot.show()
```