Blurb: A System View of Communications: From Signals to Packets (Part 2)

In this part, you will continue to gain first-hand experience building a communication system. We will show you how multiple senders can share a channel, using a technique called frequency division multiplexing, which is commonly used in wireless communications. Along the way, we will introduce the idea of examining signals in the frequency domain, and how we can use this concept to understand compression algorithms, such as the MP3 standard we commonly use to compress music files. We will discuss how we can interpret the operation of a linear time invariant channel as a filter, and how filters are used in communication systems. We also discuss how we can make the most efficient use of our communication channel in order to transmit as much information as possible.

This second in a series of three parts starts with a discussion of source coding, also known as compression. There are two types of compression: lossless and lossy. We start with a discussion of lossless compression and the idea of entropy. Before discussing the idea of lossy compression, we need to introduce the idea of the frequency domain analysis of signals. This enables us to understand the key steps in the MP3 encoding used for audio files. The frequency domain also allows us to get a better understanding of a linear time invariant system by interpreting its operation as a filtering process. In the final section of this part, we discuss how we can share a wireless channel by moving different signals in and out of different radio frequency ranges, via processes called modulation and demodulation. We discuss schemes for digital data transmission and how to make most effective use of the communication channel.

idea of source coding or compression. This week, we will pay particular attention to lossless compression. By the end of this week, you should be able to:

--Understand the difference between lossless and lossy source coding

--Calculate the entropy of a discrete random variable

--State the relationship between the entropy and the average code length

--Find a Huffman code for a set of symbols

idea of the frequency domain. This concept will be important in understanding one way in which we can share a channel as well as in giving us an alternative way of understanding the operation of a linear time invariant system. This week we will focus on how it can be used to understand the MP3 encoding we use to compress our music files. By the end of this week, you should be able to:

--Understand the parameters that control the shape of continuous and discrete time sinusoids

--Recognize that signals can be represented as sums of sinusoids.

--Reconstruct a signal given its Fourier coefficients

--Understand the key steps in MP3 encoding.

use your understanding about the frequency domain to obtain additional insight into the operation of linear time invariant systems, by viewing it as a filter which passes or even amplifies some parts of the input and blocks others. We will also study an alternative representation of the frequency domain. By the end of this week, you should be able to:

--Understand the frequency response of a linear time invariant system

--Recognize different types of filters from their frequency response

--Predict the output of a filter given the Fourier coefficients of its input and its frequency response

--Understand the complex exponential

--Understand the relationship between the discrete Fourier series and the discrete Fourier Transform.

learn about how wireless communication systems can share a common channel using a technique known as frequency division multiplexing. By the end of this week, you should be able to:

--Understand the concept of frequency division multiplexing

--Understand how modulation and demodulation can be used to shift signals from one part of the

frequency spectrum to another

--Analyze modulation and demodulation using sine waves and complex exponentials

--Understand the effect of frequency and phase mismatches between the transmitter and receiver

study how we can improve the efficiency of our communication system, and study strategies for transmitting digital data over wireless communication systems. We will conclude with a review of the material we have studied in this course. By the end of this week, you should be able to:

--Understand how digital data can be transmitted wirelessly using binary phase shift keying

--Understand how quadrature phase shift keying can be used to double the rate information sent over

the same channel

--Interpret eye and constellation diagrams as indicators of the performance of a digital communication

channel

final exam contributes 50% to your course grade. It will consist of four

equally weighted parts:

--Lossless source coding and entropy

--Frequency domain, Fourier Series/Transform and Filtering

--Modulation/Demodulation

--Digital communication protocols (BPSK/QPSK)

Course Objectives:

By the end of this course, you will be able to:

Explain typical problems and tradeoffs encountered in electronic and

computer engineering systems.

Analyze simple approaches to deal with these problems and tradeoffs.

Use software tools, such as MATLAB to investigate potential solutions to

these problems and tradeoffs in order to validate the above analysis, as well

as to handle cases not amenable to simple analysis.

By the end of this week,

you will be able to:

understand the

difference between

lossless and lossy

source coding

calculate the entropy

of a discrete random

variable

state the relationship

between the entropy

and the average code

length

find a Huffman code

for a set of symbols

Topic 1: Introduction

1.1 Course Overview

Topic 2: Lossless Source

Coding: Huffman Codes

2.1 Source coding

2.2 Sequence of Yes/No

questions

2.3 Entropy of a bit

2.4 Entropy of a discrete

random variable

2.5 Average code length

2.6 Huffman code

2.7 Lab 1 - Source coding

Course OutlineBy the end of this week,

you will be able to:

understand the

parameters that

control the shape of

continuous and

discrete time

sinusoids

recognize that signals

can be represented as

sums of sinusoids

reconstruct a signal

given its Fourier

coefficients

understand the key

steps in MP3 encoding

Topic 3: The Frequency

Domain

3.1 Music

3.2 Continuous-time sinusoids

3.3 Discrete-time sinusoids

3.4 Fourier series

3.5a Lab 2 - Frequency analysis

3.5b MATLAB demo - Frequency

analysis for voice signal

3.5c MATLAB demo - Signal

reconstruction

Topic 4: Lossy Source Coding

4.1 Perceptual coding

4.2 Time frequency analysis

4.3 Masking

4.4 Non-uniform quantization

By the end of this week,

you will be able to:

understand the

frequency response of

a linear time invariant

system

recognize different

types of filters from

their frequency

response

predict the output of a

filter given the Fourier

coefficients of its input

and its frequency

response

understand the

complex exponential

understand the

relationship between

the discrete Fourier

series and the discrete

Fourier transform

Topic 5: Filters and the

Frequency Reponse

5.1 Channels as filters

5.2 Frequency response

5.3 Filter examples

5.3a: Low pass filter example

5.3b: High pass filter example

5.3c: Band pass filter example

5.4 Frequency response of the

IR channel

5.5 Lab 3 - Frequency response

Topic 6: The Discrete Fourier

Transform

6.1 Complex numbers

6.2 Complex exponentials

6.3 Aliasing

6.4 Discrete Fourier transform

By the end of this week,

you will be able to:

understand

the concept of frequency division

multiplexing understand how

modulation and

demodulation can be

used to shift signals

from one part of the

frequency spectrum

to another

Analyze modulation

and demodulation

using sine waves

understand the effect

of frequency and

phase mismatches

between the

transmitter and

receiver

Topic 7: Signal Transmission -

Modulation

7.1 Radio spectrum

7.2 Modulation

7.3 Modulation with complex exponentials

Topic 8: Signal Transmission -

Demodulation

8.1 Demodulation

8.2 Analysis of mixing using

cosines

8.3 Analysis of mixing using

complex exponentials

8.4 Filtering

8.5 Non-ideal effects

8.6 Lab 4 - Modulation

8.7 MATLAB demo - Frequency

division multiplexing

By the end of this week,

you will be able to:

understand how

digital data can be

transmitted wirelessly

using binary phase

shift keying

understand how

quadrature phase

shift keying can be

used to double the

rate information sent

over the same

channel

interpret eye and

constellation diagrams

as indicators of the

performance of a

digital communication

channel

Topic 9: IQ Modulation

9.1 Binary phase shift keying

9.2 I/Q modulation

9.3 Quadrature phase shift

keying

9.4 Constellation diagrams

9.5 Lab 5 - BPSK and QPSK

Topic 10: Summary and

Review

10.1 Source coding

10.2 Filters and the frequency

domain

10.3 Sharing a channel