University of Miami Frost School of Music
Fall 2006

MMI 504
Audio Analysis and Synthesis

3 Credit Hours
Section Q
T R 12:30–1:45
Music Engineering Classroom

Professor Colby Leider
Weeks 109
Office Hours: T 10–12, F 1:30–3 and by appointment
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Course Description

MMI 504 is an introduction to the analysis and synthesis of digital audio through a practical approach to the art and science of digital signal processing. We will learn the basics of digital signal processing theory while examining a variety of techniques for analyzing, synthesizing, and processing digital audio. Laboratories will be offered beginning the third week of classes in which you implement ideas that we have discussed in MATLAB/C++, and assembly language on a hardware digital signal processor.

This is intended to be a challenging but fun class. Be sure to keep up with the reading and homework.

Prerequisites

MMI 503. Open to MuE majors only.

Course Objectives

At the conclusion of the course, you should possess a solid foundation of the practical side of digital signal processing and current audio analysis and synthesis methods within the context of musical applications. You should know basics of digital filters, how to implement them, different techniques for synthesizing and analyzing sound, and you should be comfortable with the Fast Fourier Transform.

Instructional Methodology

Lectures will be given on sound analysis, synthesis, and digital audio signal processing and drawn from the course textbook. Concepts will be reinforced as appropriate with computer examples in MATLAB, SuperCollider, STK, Max/MSP, and/or Pd, depending on student interest, and you are encouraged to experiment with these on your own. Laboratories will reinforce concepts and teach you basic DSP assembly language programming.

Required Text

Steiglitz, K. 1996. *A Digital Signal Processing Primer*. Menlo Park, California: Addison-Wesley.

Examinations

Two examinations will be given during the semester.

Grading Policy

Attendance and Participation	10%
Homework and Pop Quizzes	15%
Laboratories	15%
Exam 1	20%
Exam 2	20%
Final Project	20%

Class Schedule

Lecture 1 (Thursday, August 24)

Course Introduction
Analysis? Synthesis? DSP?
Lab Group Assignments
Reading: Chapter 1

Lecture 2 (Tuesday, Aug 29)

Tuning forks and phasors
Your Friend, $e^{j\omega t}$
Euler's Identity

Lecture 3 (R Aug 31)

Introduction to Signal Processing in MATLAB
Direct Time-Domain Synthesis
Additive Synthesis
Reading: Chapter 2

Lecture 4 (T Sep 5)

The Wave Equation

Lecture 5 (R Sep 7)

More About the Wave Equation
AM and FM Synthesis
Introduction to SuperCollider
Reading: Chapter 3

Lecture 6 (T Sep 12)

Sampling and Quantizing

Lecture 7 (R Sep 14)

More on Sampling and Quantizing
Wavetable Synthesis
Wave-Terrain Synthesis
Reading: Chapter 4

Lecture 8 (T Sep 19)
How Digital Filters Work
Feedforward Filters

Lecture 9 (R Sep 21)
The z-Plane
Zeroes
Creating Simple Feedforward Filters
Reading: Chapter 5

Lecture 10 (T Sep 26)
Feedback Filters
Poles

Lecture 11 (R Sep 28)
Stability
Resonant Filters
Reading: Chapter 6

Lecture 12 (T Oct 3)
Comb Filters
Simple Plucked-String Filters
Use Your Voice to Pluck a String!

Lecture 13 (R Oct 5)
Allpass Filters
Introduction to Physical Modeling Synthesis
Reading: Chapter 7

Lecture 14 (T Oct 10)
Exam 1

Lecture 15 (R Oct 12)
Requirements of Frequency Transforms
Fourier Series
Introduction to DSP Assembly Programming

Lecture 16 (T Oct 17)
Periodic Sounds
Pulses, Digital Buzz
Spectral Shaping
Reading: Chapter 8

Lecture 17 (R Oct 19)

The Discrete Fourier Transform
Final Project Web Proposals Due

Lecture 18 (T Oct 24)
The Fast Fourier Transform
Frequency-Domain Synthesis
Reading: Chapter 9

Lecture 19 (R Oct 26)

Lecture 20 (T Oct 31)
The z-Transform
Convolution
Reading: Chapter 10

Lecture 21 (R Nov 2)
Filter design in MATLAB

Lecture 22 (T Nov 7)
Work on labs

Lecture 23 (R Nov 9)
No class

Lecture 24 (T Nov 14)
Using the FFT
Windowing
Spectral Modeling Synthesis (SMS)
Reading: Chapter 11 and 12
Review

Lecture 25 (R Nov 16)
Exam 2

Lecture 26 (T Nov 21)
More on Aliasing
Time-Frequency Correspondences
Granular Synthesis
FOF and Formant Synthesis
Reading: Chapters 13 and 14

Thanksgiving Break (R Nov 23)

Lecture 27 (T Nov 28)
Final Project Presentations

Lecture 28 (R Nov 30)
Final Project Presentations

Attendance Policy

You must attend class. Makeup quizzes will not be given.

Honor Code

Students will be bound by the University of Miami Honor Code. All reports, papers, written assignments, test papers, and examination papers must include a signed honor pledge that states: "On my honor, I have neither given nor received any aid on this assignment." Academic dishonesty may result in a lower grade or a failing grade for the entire course.

Disabilities

Any student with a documented disability (e.g., physical, learning, psychiatric, visual, aural, etc.) who needs to arrange reasonable accommodations must contact the instructor and Disability Services at the beginning of the semester.