AUDIO ENGINEERING & ACOUSTICS

EE 599

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E/18/334
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Abstract

This course offers an extensive examination of audio engineering, merging traditional acoustic techniques with advanced machine learning applications. Organized into six detailed modules, it spans topics from the foundational aspects of sound to sophisticated audio analysis, designed to cater to a broad audience ranging from beginners in audio engineering to seasoned professionals keen on integrating artificial intelligence into their practices.

Module 1: Basic Acoustics and Sound Theory begins with essential sound properties—frequency, amplitude, wavelength, and velocity—and extends into human auditory perception. It elaborates on the audio signal flow, comparing analog and digital signals, and explores essential signal processing operations.

Module 2: Synthesis Techniques advances from theoretical underpinnings to practical applications, focusing on synthesizer technologies. It delves into linear and non-linear synthesis, discussing basic waveforms and modulation techniques (FM, AM, RM), and their practical implementations in modern music production.

Module 3: Audio Signal Processing tackles advanced techniques like pitch estimation and manipulation with methods such as Linear Predictive Coding (LPC) and pitch scaling/shifting. It also explores vocal processing techniques including phase cancellation and spectral editing to isolate vocals from music tracks.

Module 4: Advanced Audio Analysis explores high-level methods like subspace filtering for noise reduction and signal enhancement, alongside the physics of reverberation and its digital simulation in audio workstations to enhance audio depth and spatial quality.

Module 5: Audio Data Visualization and Analysis introduces machine learning with techniques such as scalograms and advanced spectral analysis tools. This module emphasizes genre detection and classification, highlighting feature extraction and visualization techniques that aid in understanding complex audio data.

Module 6: Modern Audio Engineering with Machine Learning fully integrates machine learning with audio processing. Covering basic ML concepts and their applications in audio, it delves into specific ML techniques for audio analysis. It concludes with practical projects like designing a genre classification model and creating a speech recognition system.

For comprehensive access to all course materials, including in-depth reports, code snippets, and output demonstrations for each section, participants are encouraged to visit the dedicated **GitHub repository** at https://github.com/Narthanasiva/EE599-Audio-Engineering-E18334. This repository is a vital resource, continuously updated to reflect the latest in audio engineering and machine learning advancements.

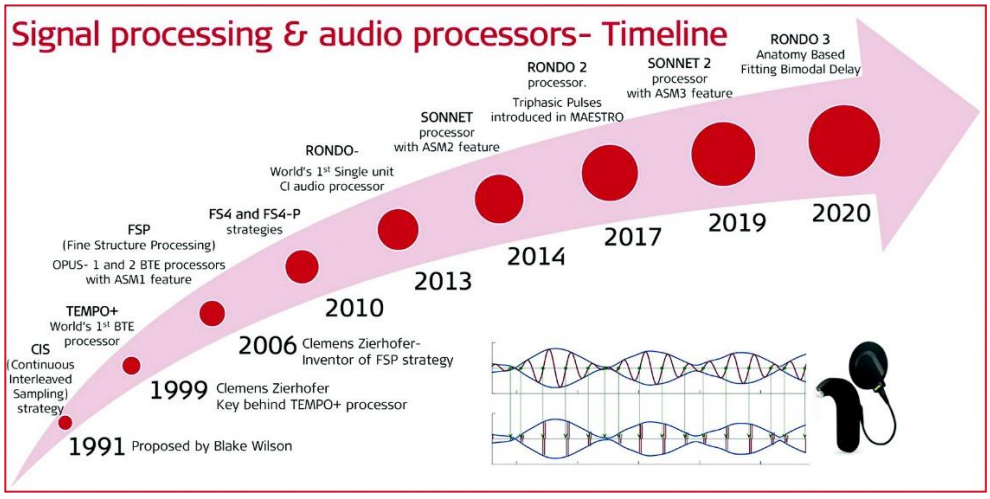
Introduction to Audio Engineering and Acoustics

GitHub Link : https://github.com/Narthanasiva/EE599-Audio-Engineering-E18334

Introduction to Audio Engineering and Acoustics

➢ What is Audio Engineering?

- **Definition of Audio Engineering**: Exploring how sound is recorded, mixed, and produced.
- **Key Components**:
    - **Recording**: Capturing sounds using microphones and other devices.
    - **Editing**: Adjusting sounds to improve quality or alter characteristics.
    - **Mixing**: Combining different sounds to create a final track.
    - **Mastering**: Enhancing the overall sound for final output.



➢ The Role of Acoustics in Audio Engineering

- **Understanding Acoustics**: The science of how sound is produced, controlled, transmitted, and received.
- **Importance in Audio Engineering**:
    - **Sound Quality**: Improving the clarity and detail of the sound.
    - **Sound Control**: Managing how sound behaves in different environments, like studios or concert halls.
    - **Equipment Design**: Developing tools that capture and reproduce sound accurately.

➢ Overview of the Course Structure

Module 1: Basic Acoustics and Sound Theory

- **Fundamentals of Sound**
  - Sound Waves: Frequency, Amplitude, Wavelength, and Velocity
  - The Human Hearing Range and Perception of Sound
- **Audio Signal Flow**
  - Analog vs. Digital Signals
  - Signal Chain and Signal Processing

Module 2: Synthesis Techniques

- **Linear Synthesizer**
  - Basic Waveforms: Sine, Square, Triangle, and Sawtooth
  - ADSR Envelope: Attack, Decay, Sustain, Release
- **Non-linear Synthesizer**
  - Introduction to Modulation Techniques: FM, AM, and RM
  - Practical Uses of Non-linear Synthesis in Modern Music Production

Module 3: Audio Signal Processing

- **Pitch Estimation and Manipulation**
  - Linear Predictive Coding (LPC): Theory and Application
  - Pitch Scaling and Shifting: Techniques and Tools
- **Vocal Processing**
  - Vocal Removal Techniques: Phase Cancellation, Spectral Editing
  - Temporal Separation: Differentiating Between Similar Sounds

Module 4: Advanced Audio Analysis

- **Subspace Filtering**
  - Theory of Subspace Methods
  - Applications in Noise Reduction and Signal Enhancement
- **Reverberation and Spatial Effects**
  - Physics of Reverberation
  - Simulating Reverb in Digital Audio Workstations

Module 5: Audio Data Visualization and Analysis

- **Visualization Techniques**
  - Scalogram: Understanding Wavelet Transforms

    - Advanced Visualization Techniques for Audio Analysis
- **Genre Detection and Classification**
    - Feature Extraction for Genre Classification
    - Practical Applications of Genre Visualization

Module 6: Modern Audio Engineering with Machine Learning

- **Introduction to Machine Learning in Audio**
    - Basics of Machine Learning
    - Applications in Audio Engineering and Acoustics
- **Machine Learning Techniques for Audio Analysis**
    - Supervised and Unsupervised Learning Models
    - Neural Networks and Deep Learning in Audio Classification
- **Practical Machine Learning Projects**
    - Designing a Genre Classification Model
    - Creating a Speech Recognition System