GCT535: Sound Technology for Multimedia

Course Introduction

Graduate School of
Culture Technology

Juhan Nam

Who We Are

- Instructor: Juhan Nam
  - Associate Professor, Graduate School of Culture Technology
  - Affiliated Professor, Kim Jaechul Graduate School of Artificial Intelligence
  - Music and Audio Computing Lab: https://mac.kaist.ac.kr/

- TAs
  - Minsuk Choi, PhD Student, GSCT
  - Jaekwon Im, PhD Student, GSCT

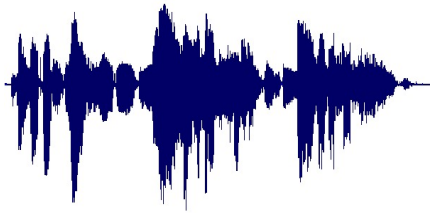
Backgrounds

- We are consuming a huge amount of multimedia content today
  - Video (e.g. YouTube)
  - Music
  - Movie
  - Drama
  - Game
  - Photograph
  - Book
  - Cartoon

Source: “Crayon Shin Chan”

Multimedia Content

- The multimedia contents are composed of three types of modalities



Text **Image** **Sound**

Sound

- Sound can be classified into three categories

Speech

- Human voice
- Narratives and textual information
- Human character and emotion

Music

- Musical instrument and singing voice
- Melody, rhythm, harmony
- Mood and aesthetics

Environmental Sound

- Event or scene sound
- Location, time, objects
- Lively and immersive feelings

Sound Technology

- We use various technologies to put the sound in multimedia contents

Recording/Synthesis → **Processing** → **Reproduction**

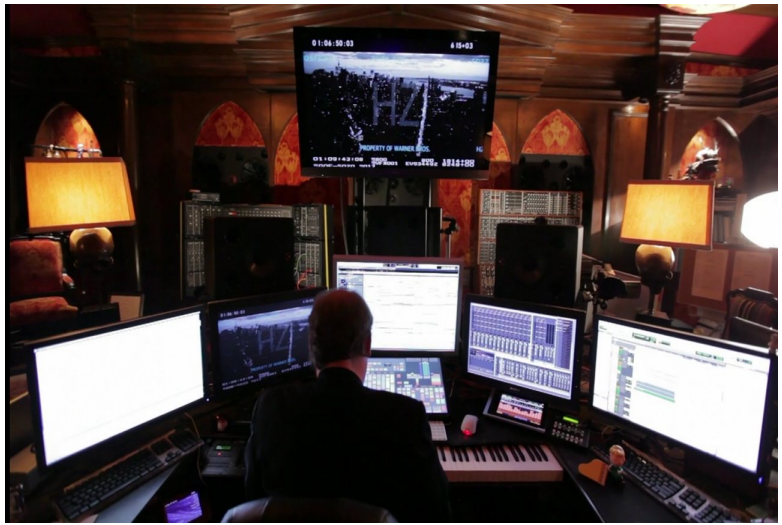
- Capture sounds with mics and convert to digital audio
- Generation tones using oscillators or samples (e.g. wavetables)

- Editing waveforms
- Denoising or source separation
- Modifying pitch, timbre, and time scale
- Audio compression
- Spectral analysis

- Spatial audio (HRTF, reverberation)
- Multi-channel speaker systems
- Binaural sound with headphones

Music production

- Digital audio workstation
  - Recording, editing, mixing, mastering
  - Virtual musical instruments, digital audio effects



Digital Audio Workstation (DAW)

Synthesizers and controllers

- Real-time audio processing and control for expressive performance
  - Physical Interfaces (e.g. keyboard, knobs, buttons, sliders, and wheels) control pitch, volume, timbre and other musical expressions

Synthesizer

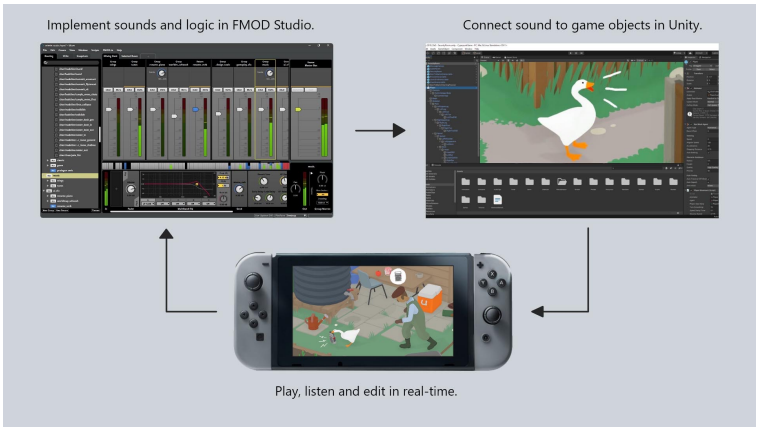
Drum Machine

Launchpad

Game Sound

- Game sound engine
  - Map actions of game characters (e.g., velocity, weight) to sound effect and its attributes (e.g., volume, timbre)
  - Foley artists imitate target sounds

Sound Effect

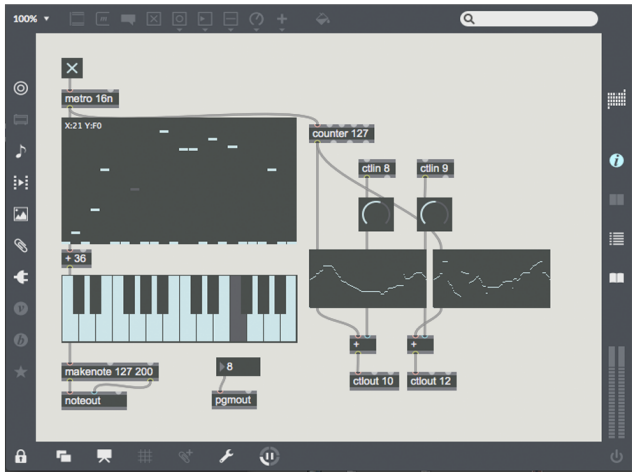


Game Sound Engine (FMOD + Unity)

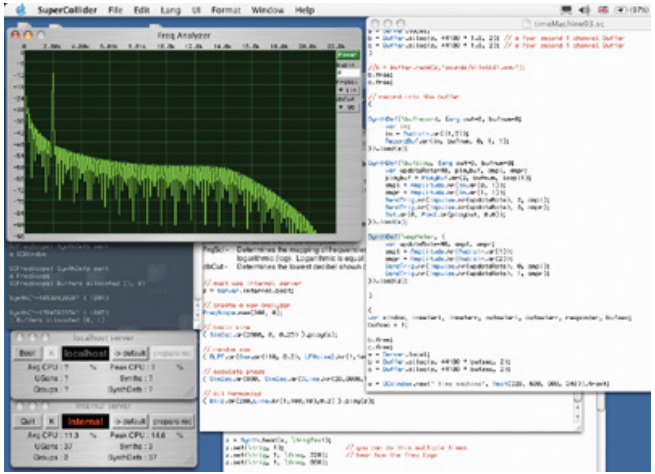
Source: https://www.asoundeffect.com/untitled-goose-game-sound/

Sound Art / Media Art

- Audio programming language
  - Example: Max, Pure data, Supercollider, Chuck
  - Allows very flexible design and control: sound synthesis, audio effects, algorithmic composition



Max



Supercollider

Course Objective

- Learning theories and applications behind the sound technologies
- Theories
  - Fundamentals of acoustics and human hearing
  - Digital signal processing: digital audio, filters, and Fourier analysis
  - Sound synthesis and digital audio effects
- Applications
  - Synthesizers and digital musical instruments
  - Music production
  - Game/Film sound
  - Sound arts

Practice

- Python with Jupyter notebook
  - Algorithm implementation, graph plot and visualization
  - Not real-time, good for debugging
- JUCE
  - C++ library to build audio plugins (VST, AU): https://juce.com/
  - Real-time, running on DAW
- DAW software
  - Audacity: https://www.audacityteam.org/
  - Reaper: https://www.reaper.fm/

Schedules

- Week 1
  - Course introduction
  - Fundamentals of acoustics: tone generation
- Week 2
  - Fundamentals of acoustics: human hearing
- Week 3
  - Digital audio
  - Discrete Fourier transform and spectral analysis
- Week 4
  - Sound synthesis: additive and subtractive

Schedules

- Week 5
  - LTI system, FIR/IIR filters, convolution
- Week 6
  - Sound synthesis: modulation and distortion
  - Comb filters and delay-based audio effect
- Week 7
  - MIDI, synthesizer, drum machine, sound design
- Week 8
  - Midterm exam

Schedules

- Week 9
  - Digital audio effect: EQ and dynamic range control
- Week 10
  - Digital audio effect: resampling, pitch shifting and time-scale modification
- Week 11
  - Spatial audio: HRTF, reverb
- Week 12
  - Sound production: music and game

Schedules

- Week 13
  - Final project idea presentation
- Week 14
  - TBD
- Week 15
  - TBD
- Week 16
  - Final project presentations

Homework

1. [Paper] Sinusoid, Sampling, DFT and STFT
2. [Paper] Digital filters
3. [JUCE] Sound synthesizer
4. [JUCE] Digital audio effect plug-in

Pre-requisites

- Basic engineering literacy
  - Mathematics: complex number, cos, sin, log, …
  - Programming language: basic level of Python and C++

- Signals and Systems
  - LTI systems, filters, frequency response, z-transform, Fourier Transforms
  - Desired but not required

Textbooks

- Fundamental of DSP
  - Mathematics of the Discrete Fourier Transform (DFT), Julius O. Smith III
  - Introduction to Digital Filters (with audio applications), Julius O. Smith III
- Digital audio effects
  - DAFx: Digital Audio Effects (2nd Eds.), Udo Zolzer
- Synthesizer and sound design (musical sound)
  - The Theory and Technique of Electronic Music, Miller Puckette
- Sound design (environmental sound)
  - Designing Sound, Andy Farnell (not free)

Grading

- Midterm: 20%
  - Written exam
- Assignments: 50%
  - Python, JUCE
- Final Project: 30%
  - Team project: up to 2 students
  - Format
    - Proposing algorithms or methods for sound
    - Implementing audio plug-ins, synthesizers or other audio tools
    - Creating sound content: sound design, sound art, etc.
  - Report

Course Information

- Course webpage
  - https://mac.kaist.ac.kr/~juhan/gct535/
  - Basic course info, schedule, resources
- GitHub page
  - https://github.com/juhannam/gct535-2022
  - Manage practice code and homework
- KLMS / Classum
  - Announcement
  - Question and Answers
  - Homework
  - Grading