CTP431: Fundamentals of Computer Music

Digital Sound Synthesis – Part 3

Graduate School of
Culture Technology

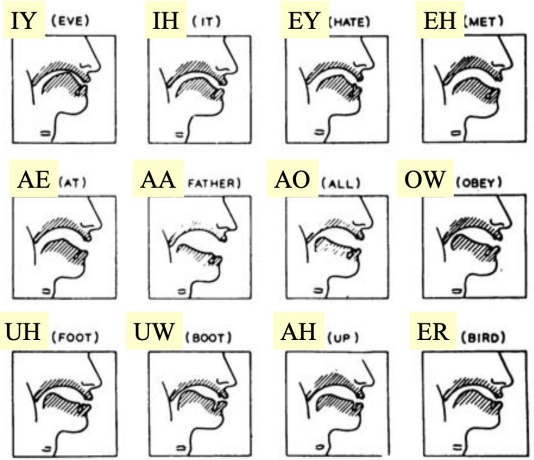
Juhan Nam

Outlines

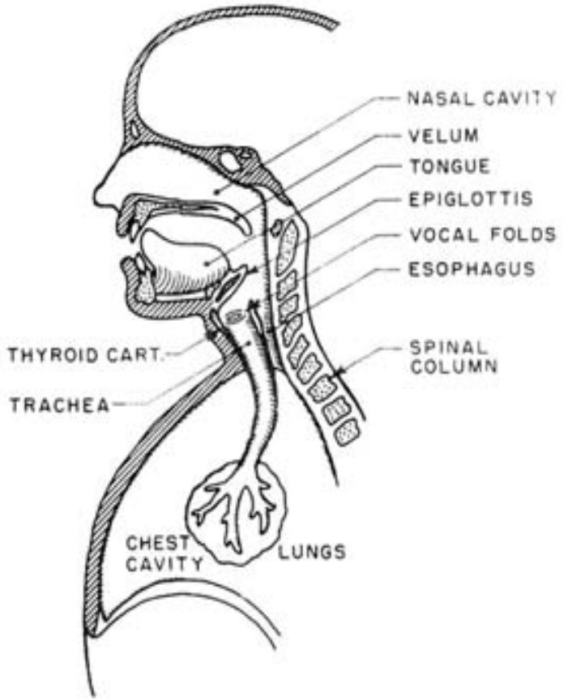
- Speech synthesis and vocoder
- Granular synthesis
- Game sound design

Speech production

- Vocal cords: oscillation of air flow
- Vocal tract: air pathway to the mouth
  - Throat + tongue + lips
  - Changes to pronounce different vowel sounds
  - Resonances at different frequencies



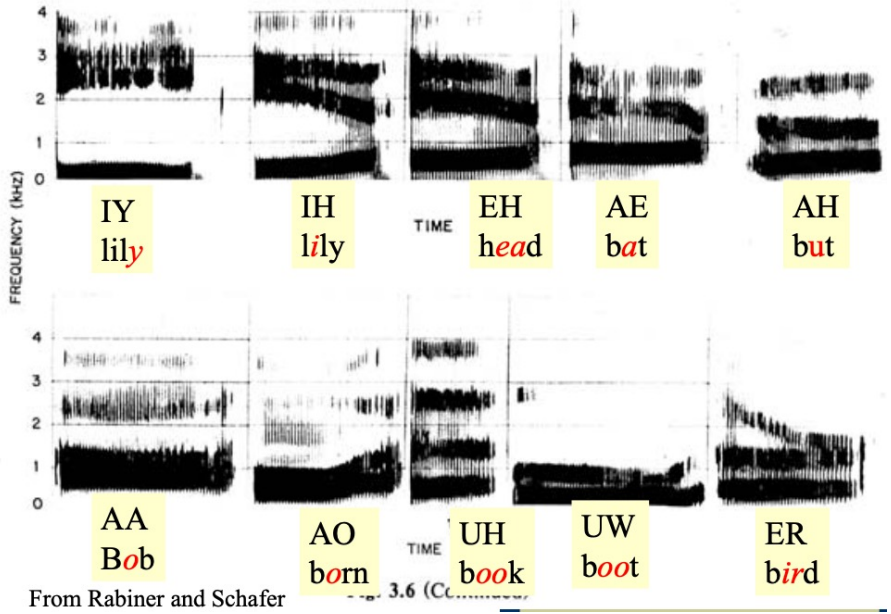
From Flanagan



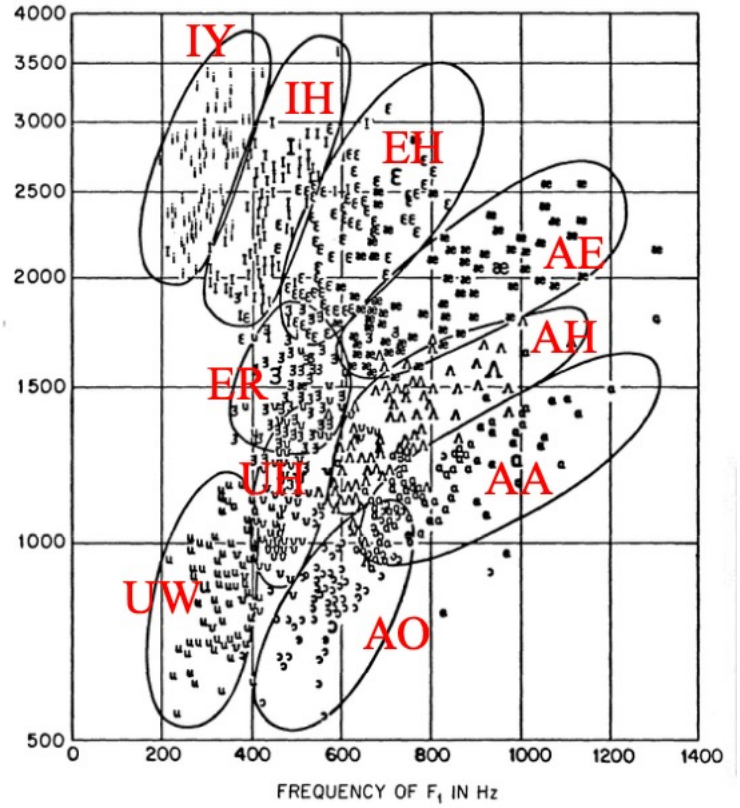
From Rabiner and Juang

Speech Waveform

- Vowel and Formant

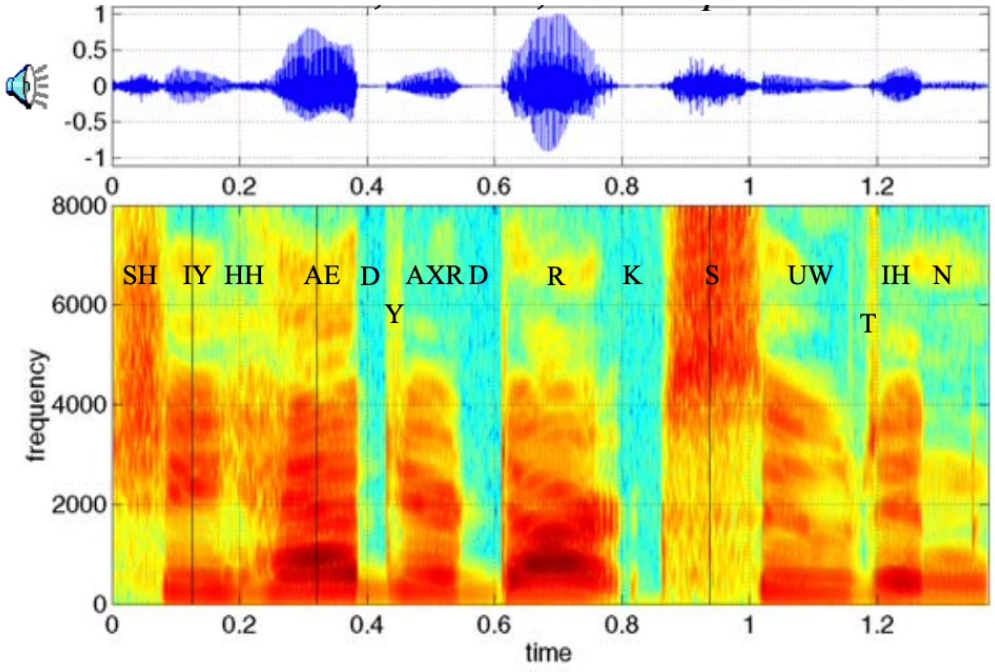


From Rabiner and Schafer



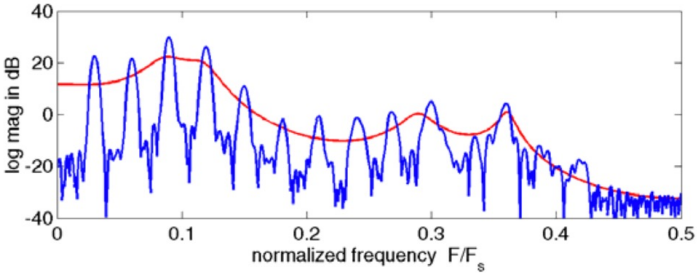
Speech Waveform

- Consonant sounds: soft and noisy waveform
- Vowel sounds: loud and periodic waveform

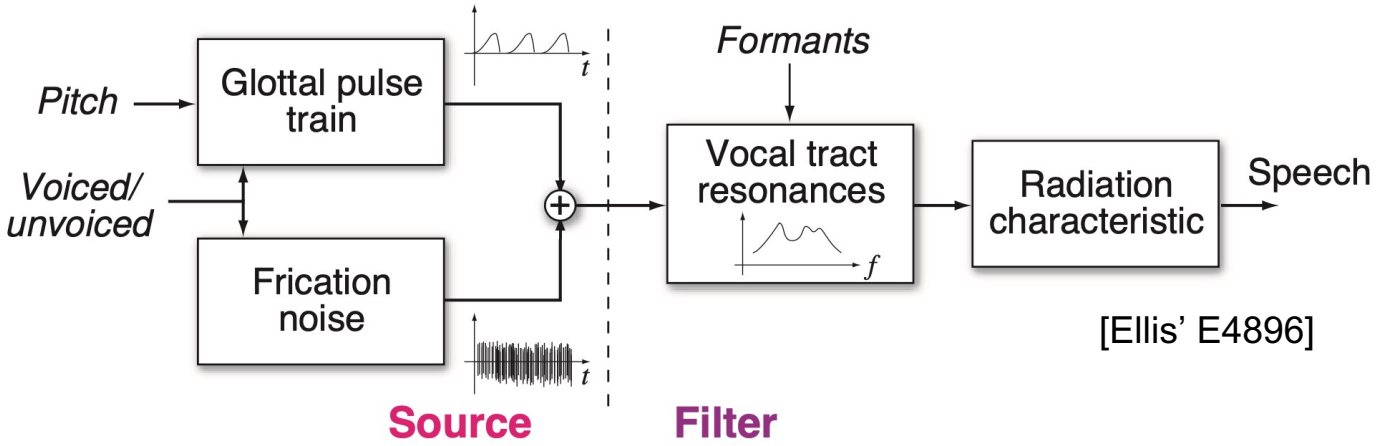


Speech Synthesis

- Source-filter model
  - Source: oscillator or noise
  - Filters: shape the formant



Spectrum and format of a vowel sound

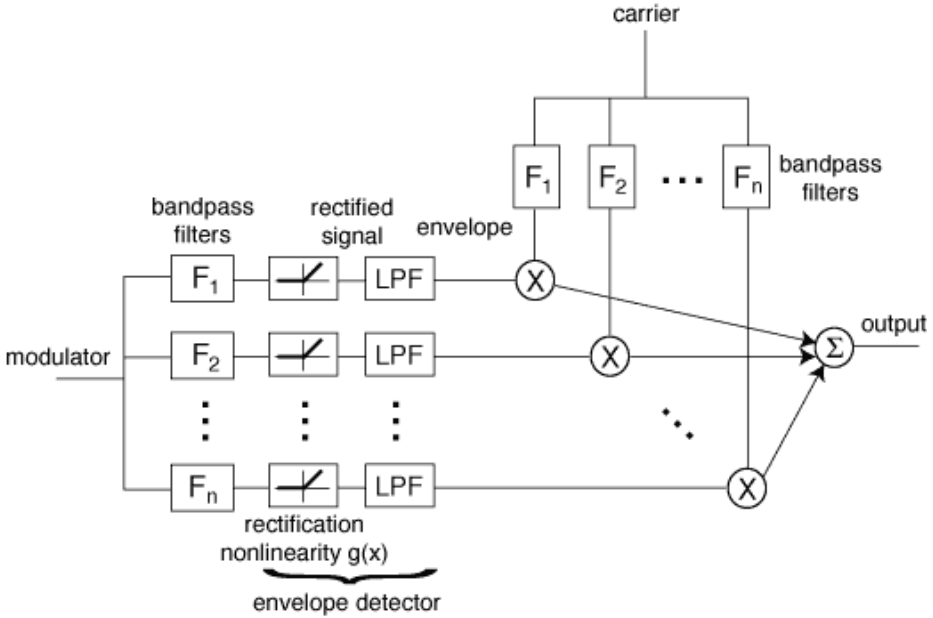


[Ellis' E4896]

Fun example: https://artsandculture.google.com/experiment/blob-opera/AAHWrq360NcGbw?hl=en

Channel Vocoder

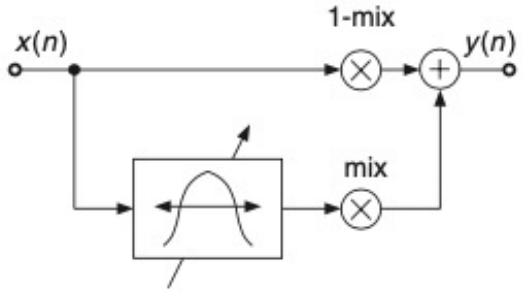
- Extract formants using a filterbank and use them to modulate a wideband carrier signal



https://www.youtube.com/watch?v=LoHm9q-a1R0

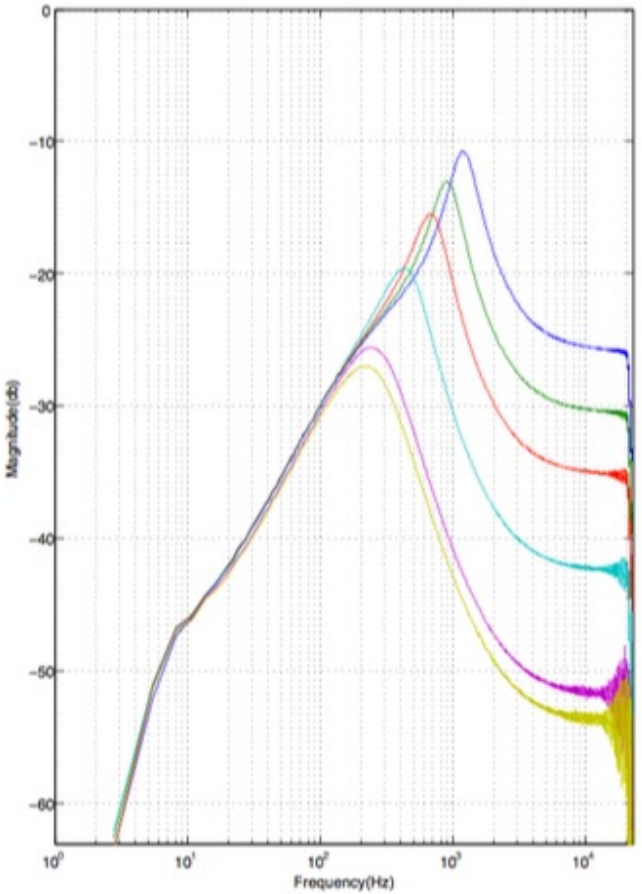
Wah-Wah Effect

- Emulate a human-voice-like sound using resonant filters
  - Bandpass filters or resonant lowpass filters model “formant”
  - The formant frequency ranges between 400 Hz and 2000 Hz, and it is often controlled by a foot pedal
    - https://www.youtube.com/watch?v=NW9Yq99FeTU
  - Implemented with a cascade of bandpass filter and resonant lowpass
    - http://www.geofex.com/article_folders/wahpedl/voicewah.htm



Wah-Wah Effect Diagram (DAFx book)

Wah-Wah Effect



Ampltiude response

Dunlop 535Q CryBaby

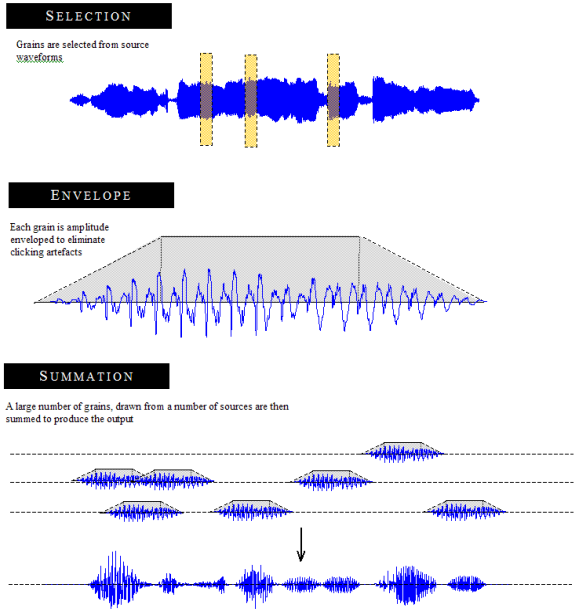
Auto-Wah Effect

- The center frequencies can be also controlled automatically by several controllers
  - Envelope follower
    - Compute the trajectory of amplitude envelope
  - Low frequency oscillator (LFO)
    - A sinusoid or sawtooth waveform with a low frequency (typically less than 5 Hz)
  - Used for guitar, bass guitar, clavinet, and electric piano
    - https://www.youtube.com/watch?v=aOmsLKqqJcQ (electric piano)
    - https://www.youtube.com/watch?v=Ws86GIm_jS0 (Clavinet by Stevie Wonder)

Granular Synthesis

- Take small grains of samples from recorded audio and play them as “a cloud” to generate a sound texture
  - The grain is the quantum of sound

- Parameters
  - Grain size: 1 to 50ms
  - Grain envelope: attack and release time
  - Grain density: overlap



(Williams and Murray-Smith, 2003)

Granular Synthesis

- Demos
  - https://www.youtube.com/watch?v=1RWOoEj3mwU
  - https://www.youtube.com/watch?v=Mb4EEWedQKM

- Car sound synthesis
  - https://www.youtube.com/watch?v=1-YxAmMn-hM

Game Sound

Journey (2012) (https://www.youtube.com/watch?v=bkL94nKSd2M)

Types of Game Sound

- Effects
  - Event-driven sound: action, object recognition
    - Local, transient: shooting, crashing, exploding
    - Continuous: driving
  - Produced by foley artists

- Background sound / music
  - Mood, context (e.g., success, battle and game over)
  - Produced by composers

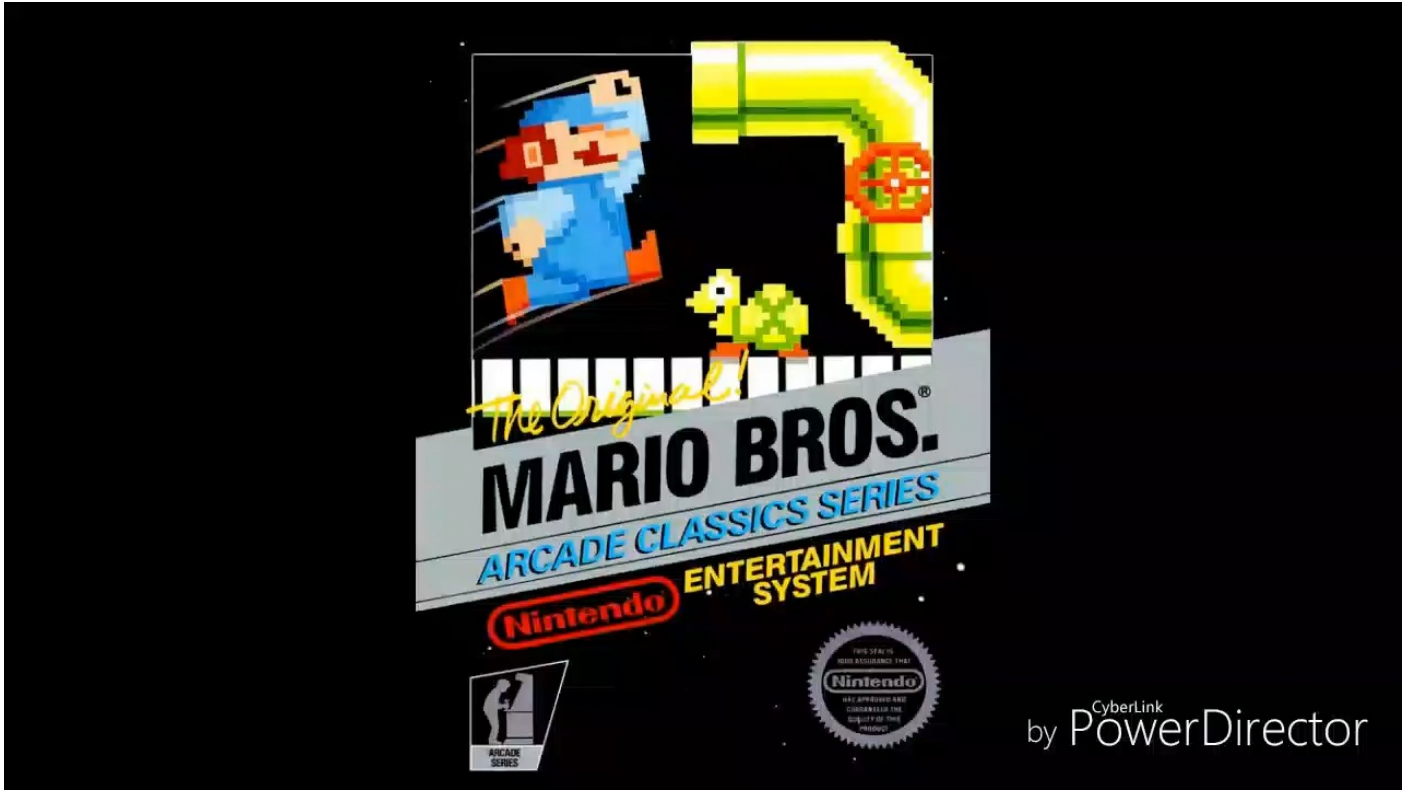
Foley Sound

https://www.youtube.com/watch?v=TuDSPkxq4D4

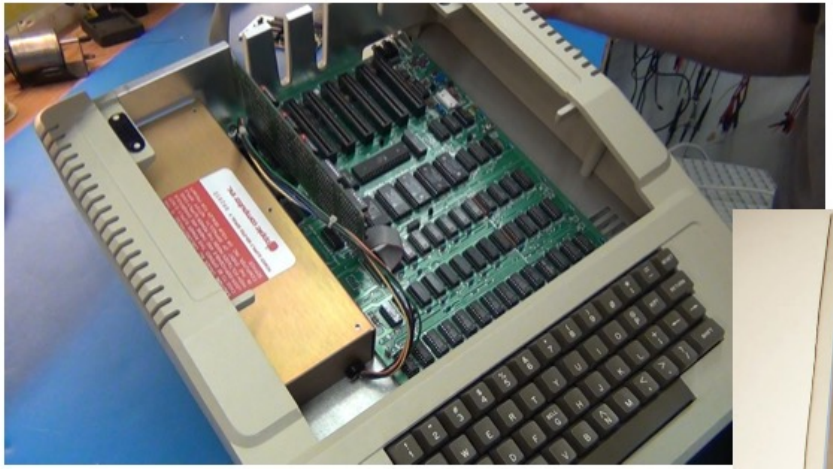
Foley Sound

https://www.youtube.com/watch?v=6grv9UqpyAw

Background Music: “Game Over” Collections



https://www.youtube.com/watch?v=qIxpvsE2Zgw



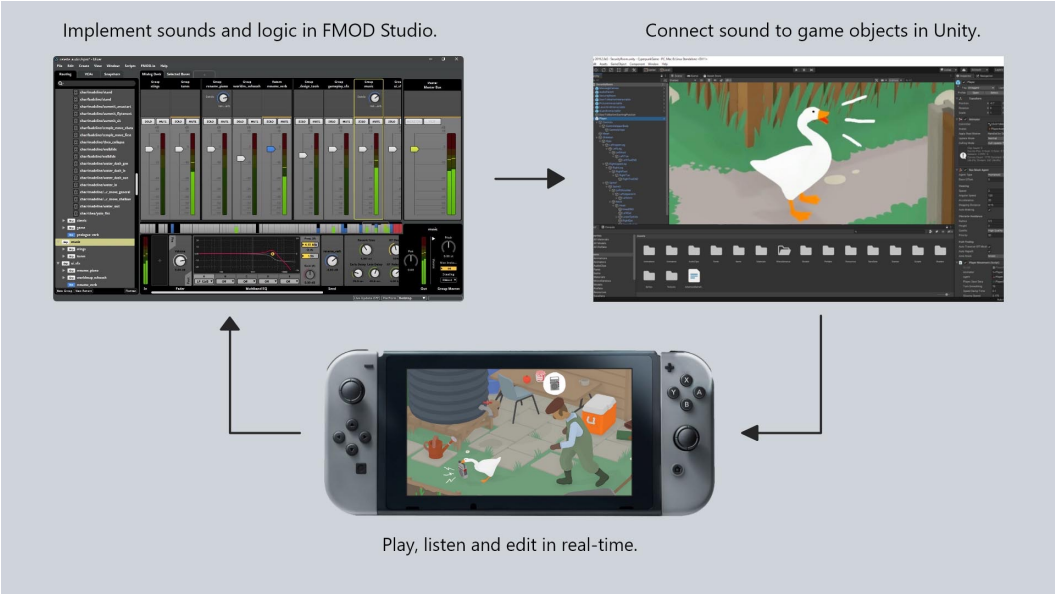
Apple II Computer

Apple II Mockingboard


Lord British
AND
ORIGIN SYSTEMS, INC.
PRESENT
Ultima IV
QUEST OF THE AVATAR

Sound Effect Engine

- Interactive audio signal processing for game
  - Map character motions to sound and control parameters
  - FMOD, WWISE: integrated with main game engines (Unity, Unreal engine)



Adaptive Audio

Untitled Goose Game (2019) (https://www.youtube.com/watch?&v=5OrLdnOUEkY)