Hands-on Coding Session II
Music Visualization

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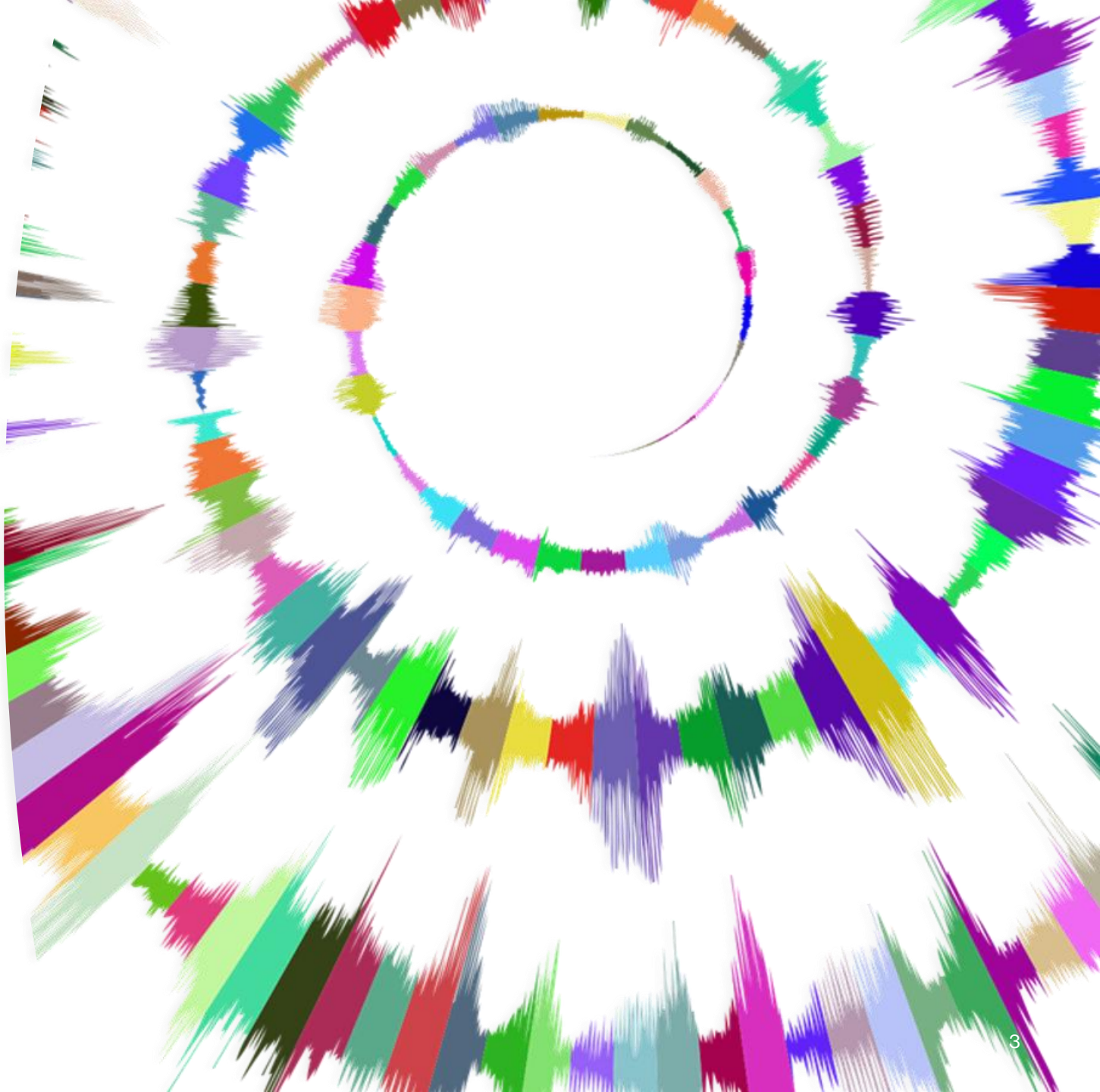
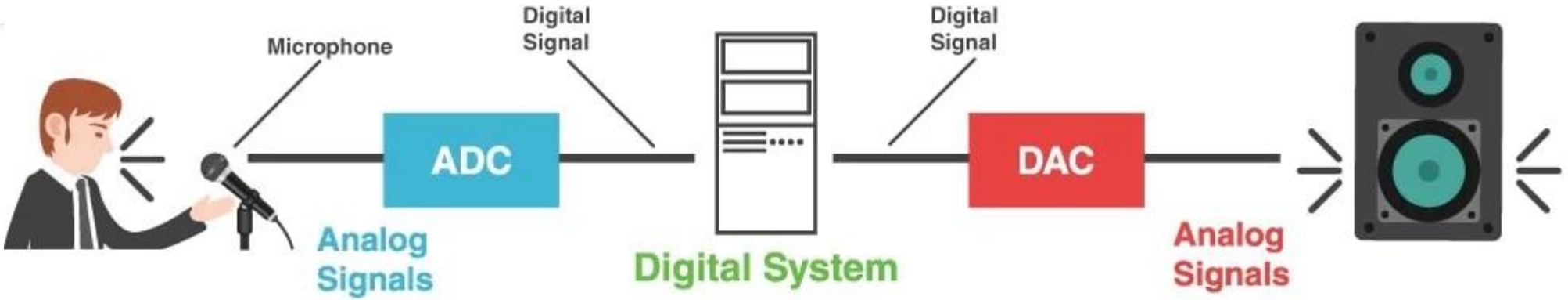
Introduction

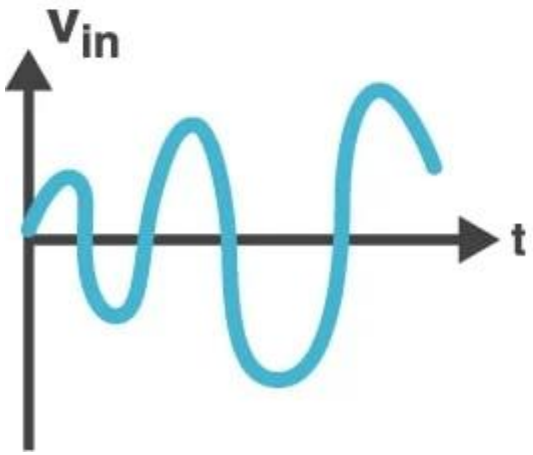
Music Visualization

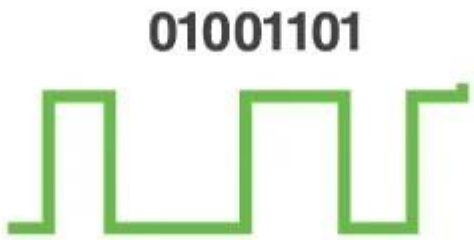
- The process of creating visual representations of audio signals, such as music.
- To provide a way to analyze and understand audio signals, and to create visually appealing representations of audio signals for artistic or entertainment purposes.

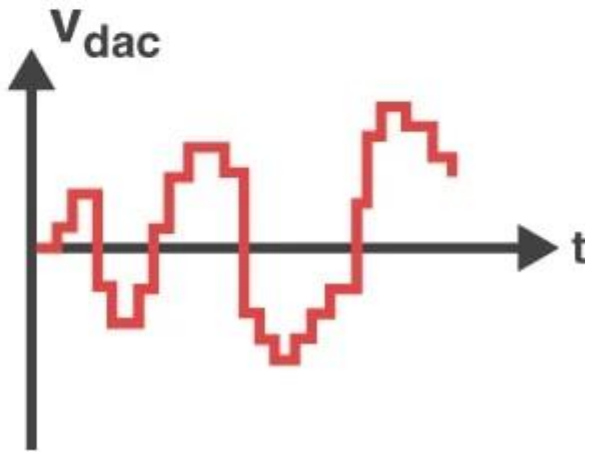


Audio signal processing

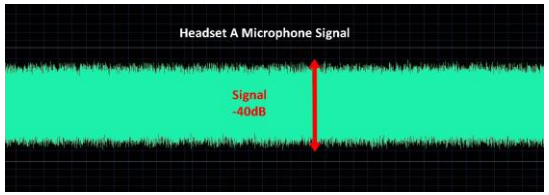


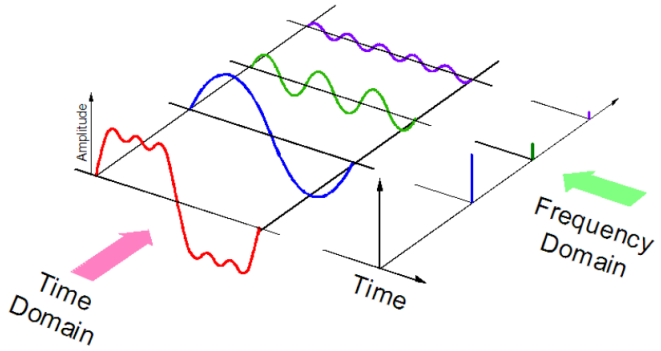


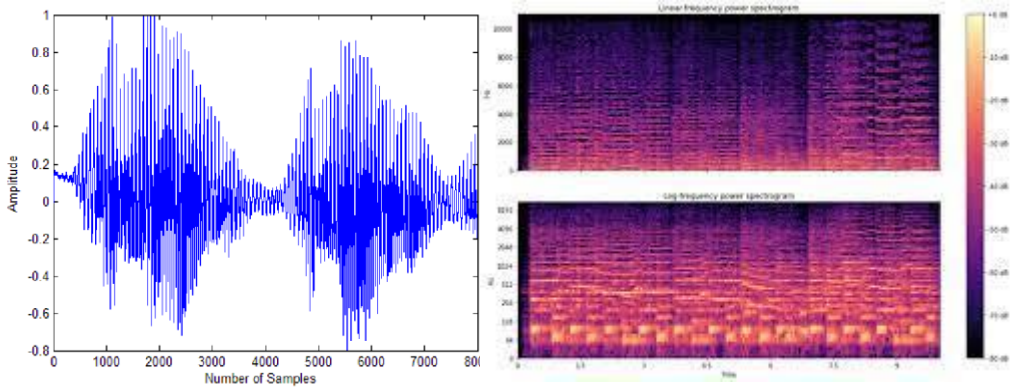




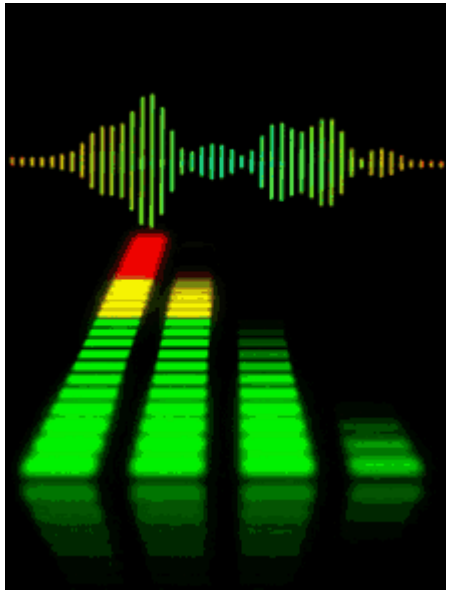
Audio input → Signal Processing → Data Representation



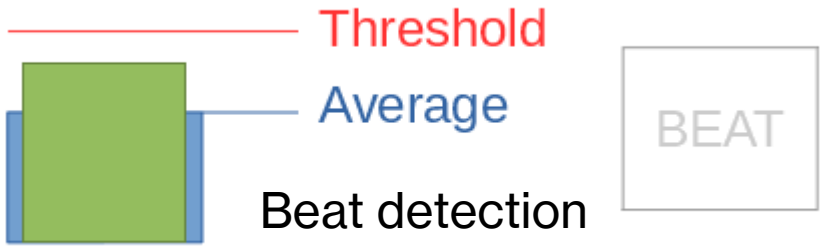




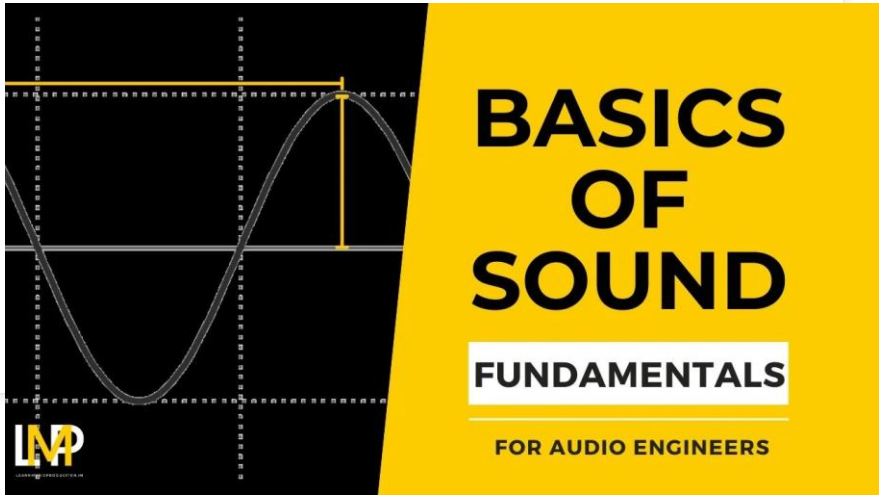
Workflow



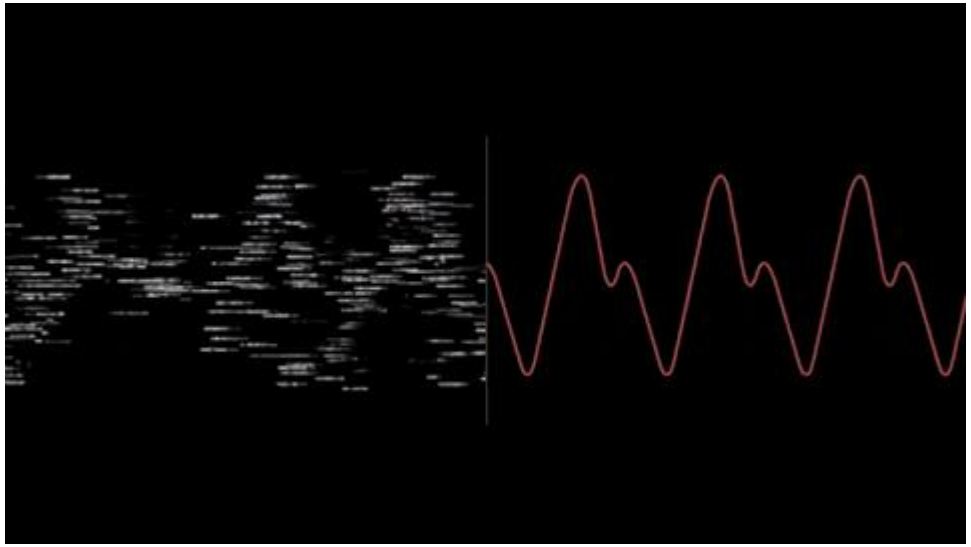
Visualization

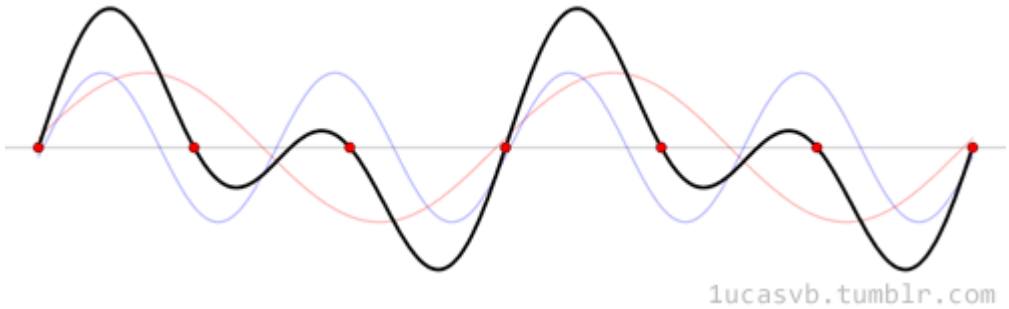


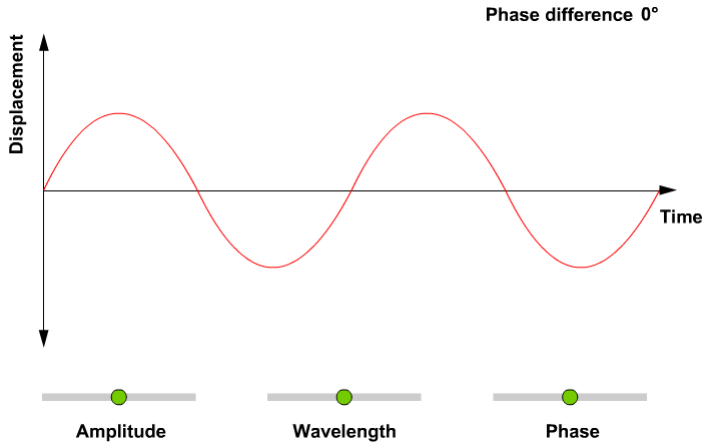
Significance in Audio Engineering



- Importance of visualizing audio signals to understand frequency content, structure, and changes over time.
- Applications in music production, sound design, and research.



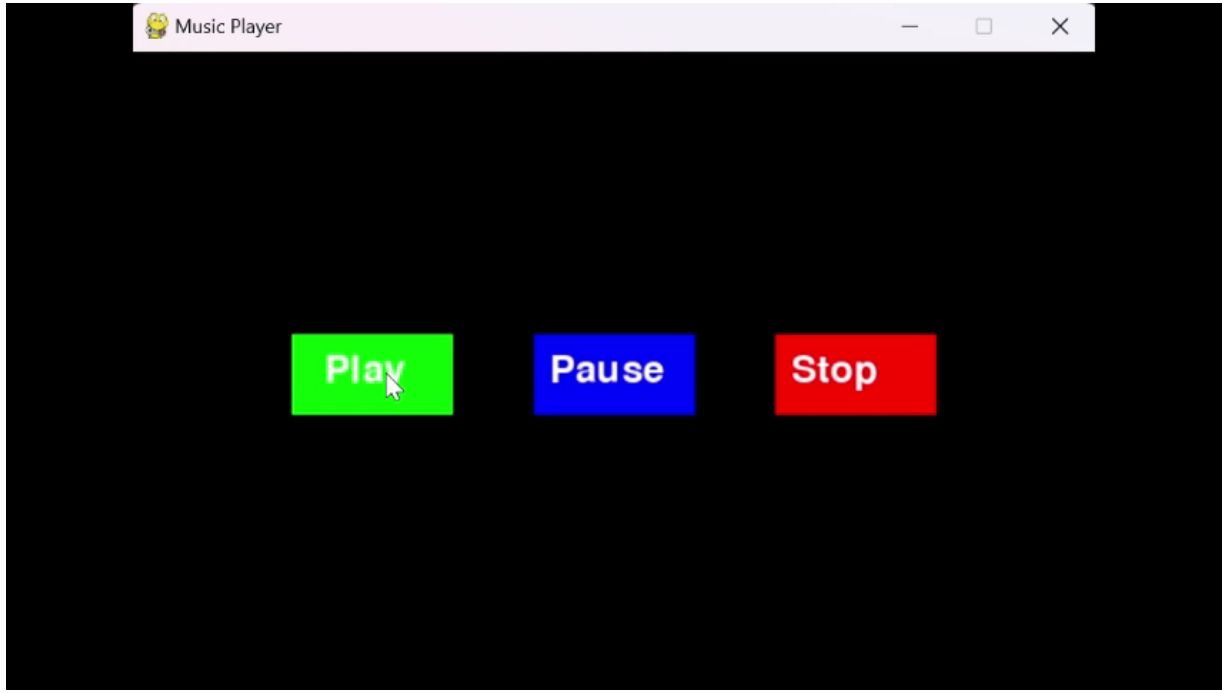




01- Create Music control buttons

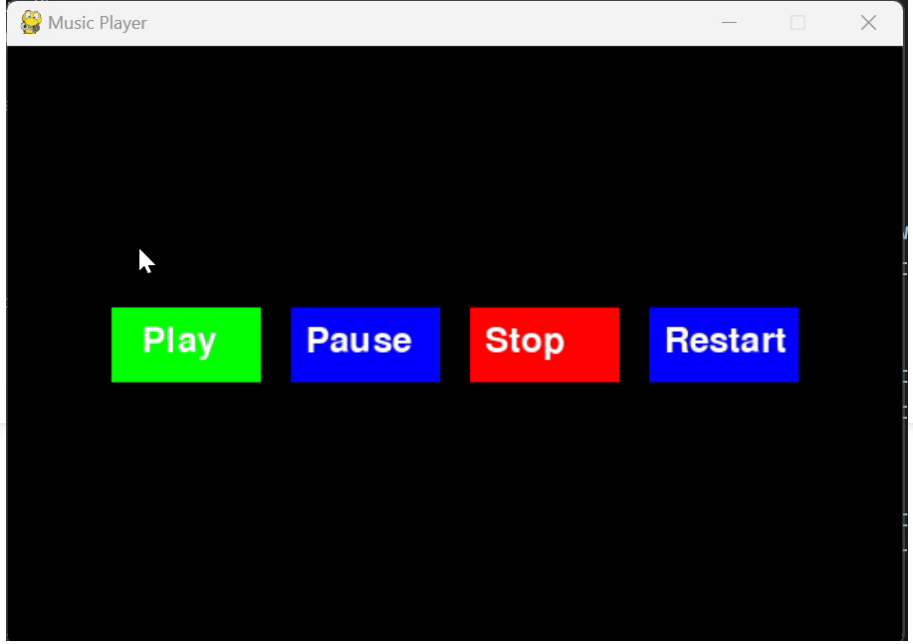
Task01-starter_music_playback

```
def draw_buttons():
    # Draw the play button
    pygame.draw.rect(screen, GREEN, play_button)
    play_text = font.render('Play', True, WHITE)
    screen.blit(play_text, (play_button.x + 20, play_button.y + 10))

    # Draw the pause button
    pygame.draw.rect(screen, BLUE, pause_button)
    pause_text = font.render('Pause', True, WHITE)
    screen.blit(pause_text, (pause_button.x + 10, pause_button.y + 10))

    # Draw the stop button
    pygame.draw.rect(screen, RED, stop_button)
    stop_text = font.render('Stop', True, WHITE)
    screen.blit(stop_text, (stop_button.x + 10, stop_button.y + 10))
```



Task01_Implement “Restart” Button

“Restart” Button



1. Add a Restart Button

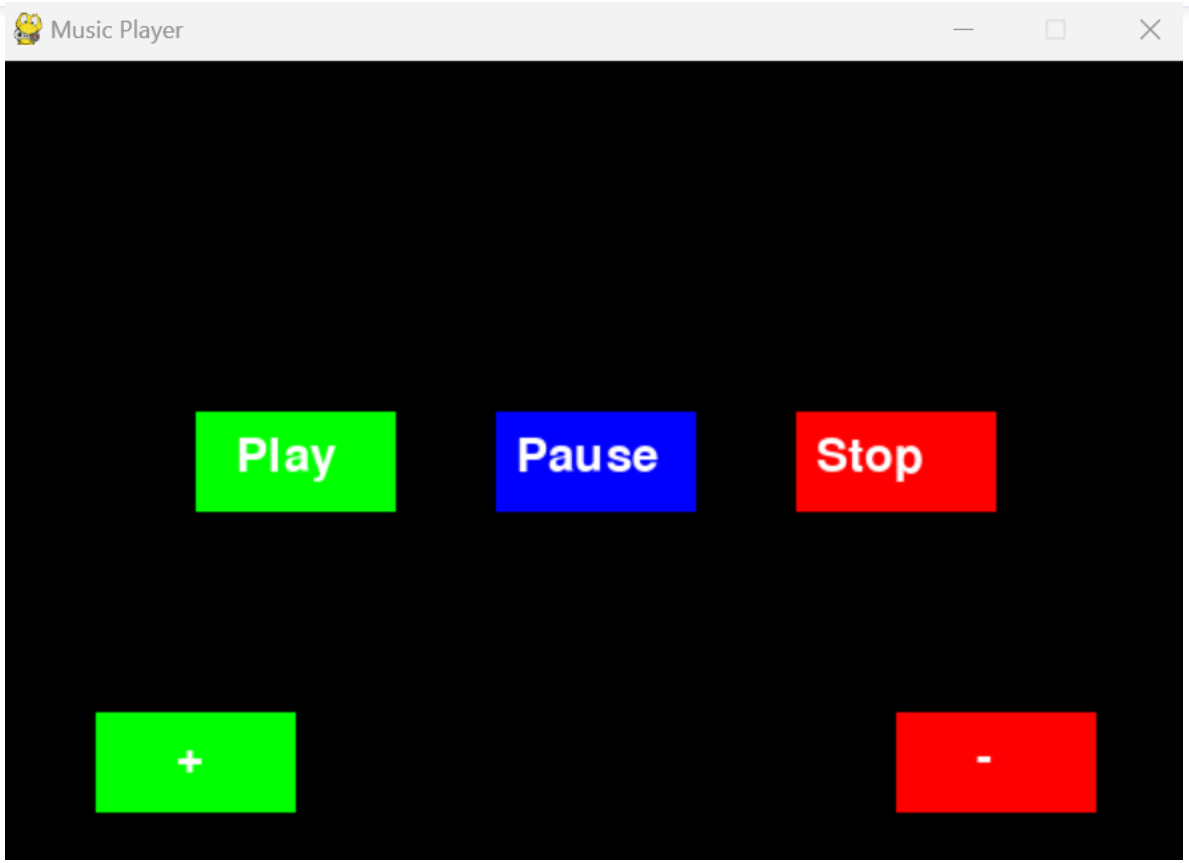
```
restart_button = pygame.Rect(4 * WIDTH // 5 - button_width // 2, HEIGHT // 2 - button_height // 2, button_width, button_height)
```

2. Draw the Restart Button
3. Implement the Restart Button Functionality

```
elif restart_button.collidepoint(event.pos):  # Check if Restart button is clicked
        pygame.mixer.music.play(start=0)  # Restart the music from the beginning
```

02-Volume Up and Down Buttons

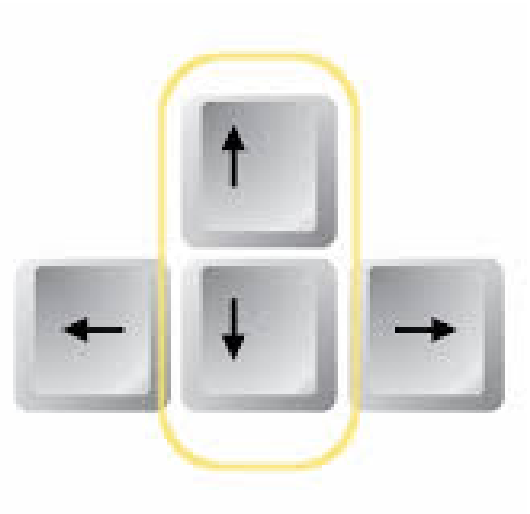
02-volumnButtons_music_playback



Task02-Adjust the Volume with Keyboard Keys

Task02-Adjust the Volume with Keyboard Keys

```
elif event.type == pygame.KEYDOWN:
        if event.key == pygame.K_UP:  # Increase volume
            current_volume = increase_volume(current_volume)
        elif event.key == pygame.K_DOWN:  # Decrease volume
            current_volume = decrease_volume(current_volume)
```



Task03: Create Volume Control Module

- Goal: Create a volume_control.py module that defines functions to increase and decrease the music volume. Integrate this module with the main PyGame music player script (main.py) to control the volume using keyboard inputs.

volume_control.py

```
import pygame

def increase_volume(current_volume, increment=0.1):
    new_volume = min(current_volume + increment, 1.0)
    pygame.mixer.music.set_volume(new_volume)
    return new_volume

def decrease_volume(current_volume, decrement=0.1):
    new_volume = max(current_volume - decrement, 0.0)
    pygame.mixer.music.set_volume(new_volume)
    return new_volume
```

main.py

```
import pygame
import sys
from volume_control import increase_volume, decrease_volume

# Initialize PyGame, set up the display, and load music as before

current_volume = pygame.mixer.music.get_volume()

# Main game loop
running = True
while running:
    for event in pygame.event.get():
        if event.type == pygame.QUIT:
            running = False
        elif event.type == pygame.KEYDOWN:
            if event.key == pygame.K_UP:  # Increase volume
                current_volume = increase_volume(current_volume)
            elif event.key == pygame.K_DOWN:  # Decrease volume
                current_volume = decrease_volume(current_volume)

    # Fill the screen, draw UI elements, etc.

    pygame.display.update()

pygame.quit()
sys.exit()
```

03-audioProcesswithNumpy

03-audioProcesswithNumpy

This normalization and scaling process allows the waveform to be visually represented in a way that maximally utilizes the available space

```
amplitude = np.interp(signal, (signal.min(), signal.max()), (0, HEIGHT))
```

Task04_Stop and Play Music with Keyboard Keys


```
elif event.type == pygame.KEYDOWN:
            # Stop music if the 's' key is pressed
        if event.key == pygame.K_s:
            pygame.mixer.music.stop()
         # Play music if the 'p' key is pressed
        if event.key == pygame.K_p:
            pygame.mixer.music.play()
```

04-fileMenu_music_playback

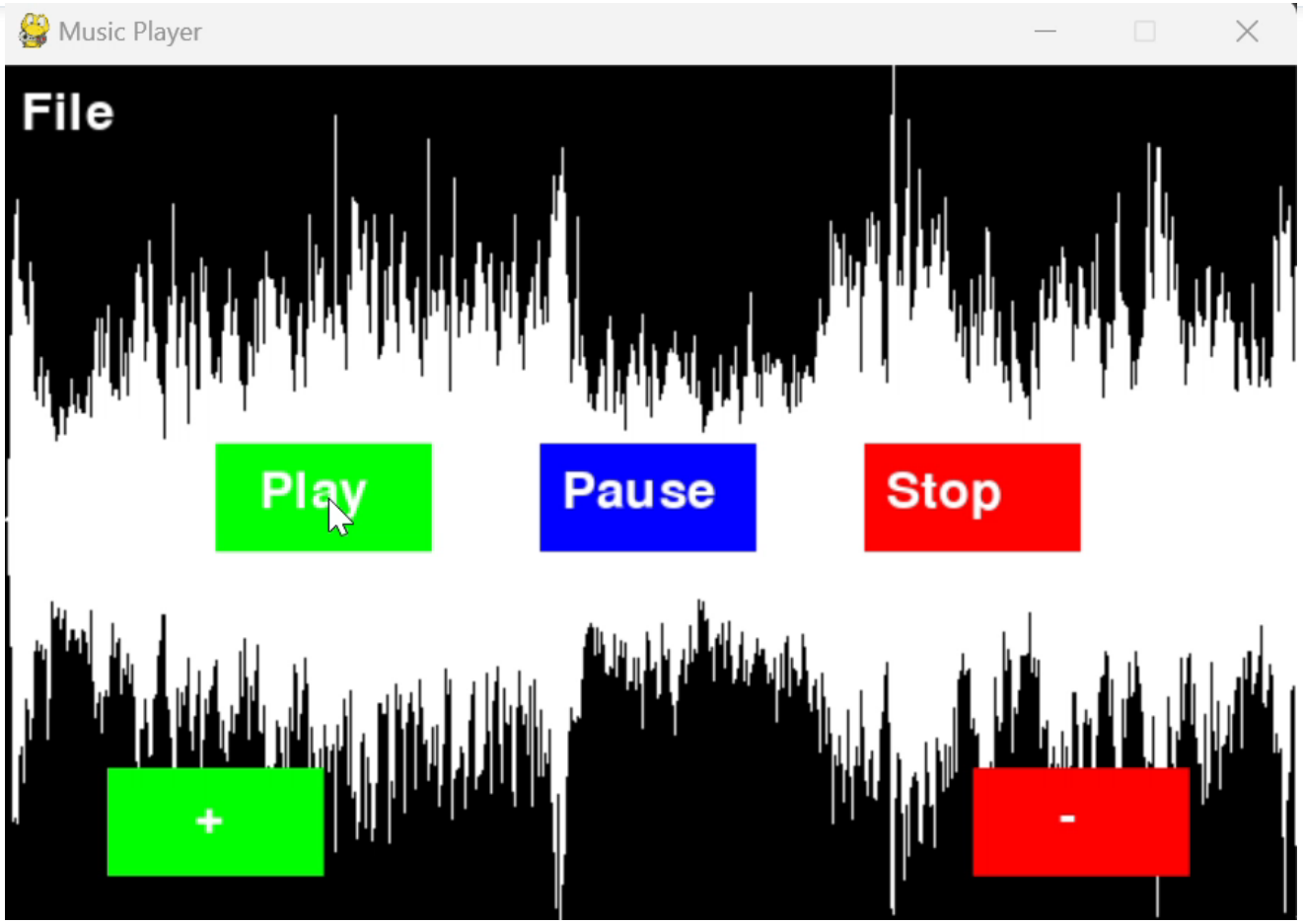
04-fileMenu_music_playback

import tkinter as tk

Task05_Create Music Player Module

Task05_Create Music Player Module

1. volume_control.py
2. audio_visualization.py
3. filemenu.py
4. main.py



Additional Resources

Music Visualizer by Beat Detection

1. Libraries Installation

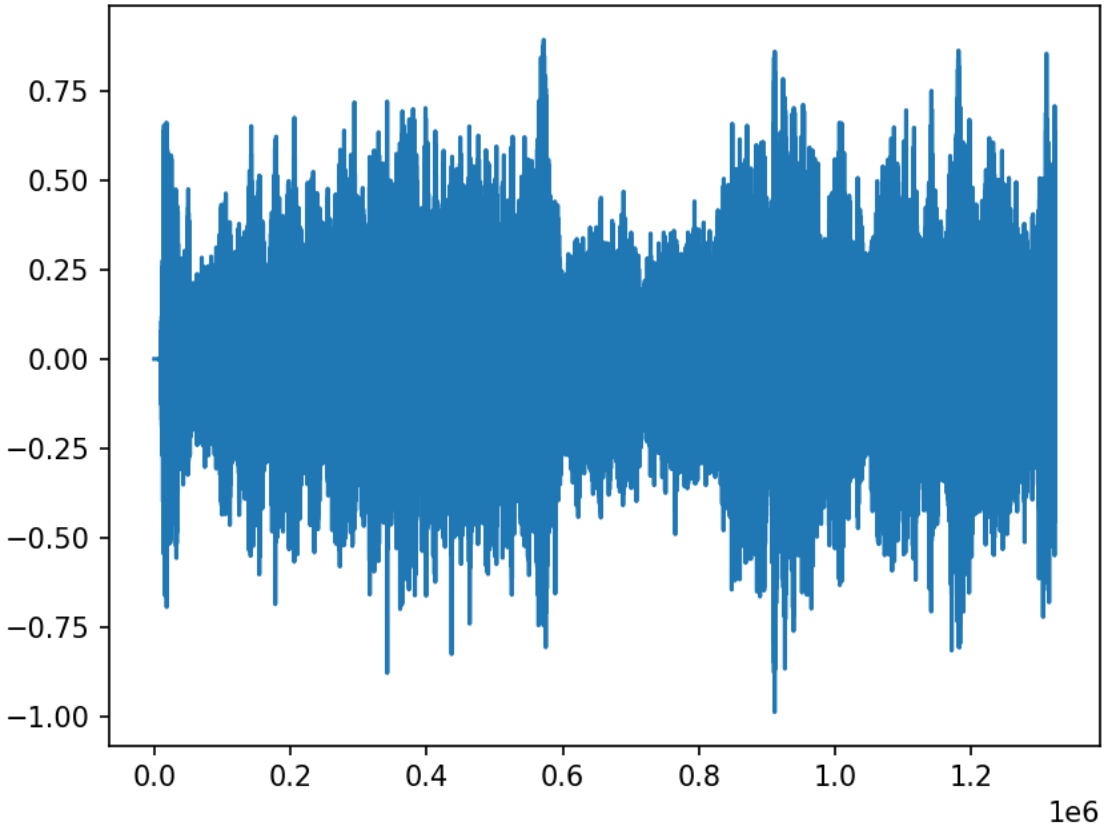
- Pygame
- Numpy
- Sounddevice
- soundfile
- Matplotlib
- Aubio
- Pydub
- librosa

pip install numpy scipy librosa pydub aubio matplotlib soundfile

2. Audio visualization

```
import numpy as np
import sounddevice as sd
import matplotlib.pyplot as plt
import soundfile as sf


# Load the audio file
filename = 'StarWars60.wav'
#data, samplerate = sd.read(filename)
data, samplerate = sf.read(filename, dtype='float32')

# Get the average amplitude of the audio data
average_amplitude = np.mean(np.abs(data))
print(average_amplitude)
# Plot the audio data
plt.plot(data)

# Show the plot
plt.show()
```

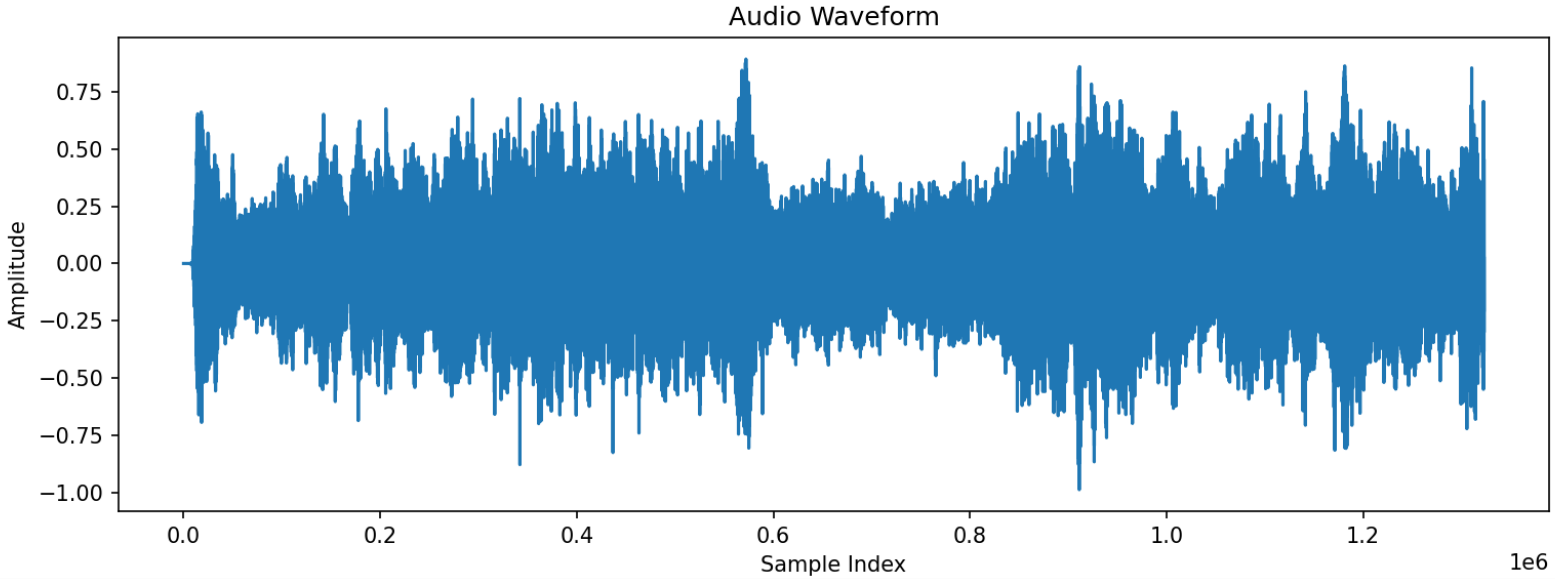
Displaying waveform



3. Pydub library

- Convert audio data to numpy array using pydub

```
from pydub import AudioSegment
import numpy as np
import matplotlib.pyplot as plt

def display_waveform(file_path):
    audio = AudioSegment.from_file(file_path)

    # Convert audio data to numpy array
    audio_data = np.array(audio.get_array_of_samples())
    audio_data = audio_data / (2**15)

    # Plot the audio data
    plt.figure(figsize=(12, 4))
    plt.plot(audio_data)
    plt.title('Audio Waveform')
    plt.xlabel('Sample Index')
    plt.ylabel('Amplitude')
    plt.show()

# Replace "your_audio_file.mp3" with the path to your audio file
file_path = "StarWars60.wav"
display_waveform(file_path)
```



3. Pydub library

- Convert audio data to numpy array using pydub

```
audio_data = audio_data / (np.mean(np.abs(audio_data)))
```

```
from pydub import AudioSegment
import numpy as np
import matplotlib.pyplot as plt

def display_waveform(file_path):
    audio = AudioSegment.from_file(file_path)

    # Convert audio data to numpy array
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# Replace "your_audio_file.mp3" with the path to your audio file
file_path = "StarWars60.wav"
display_waveform(file_path)
```
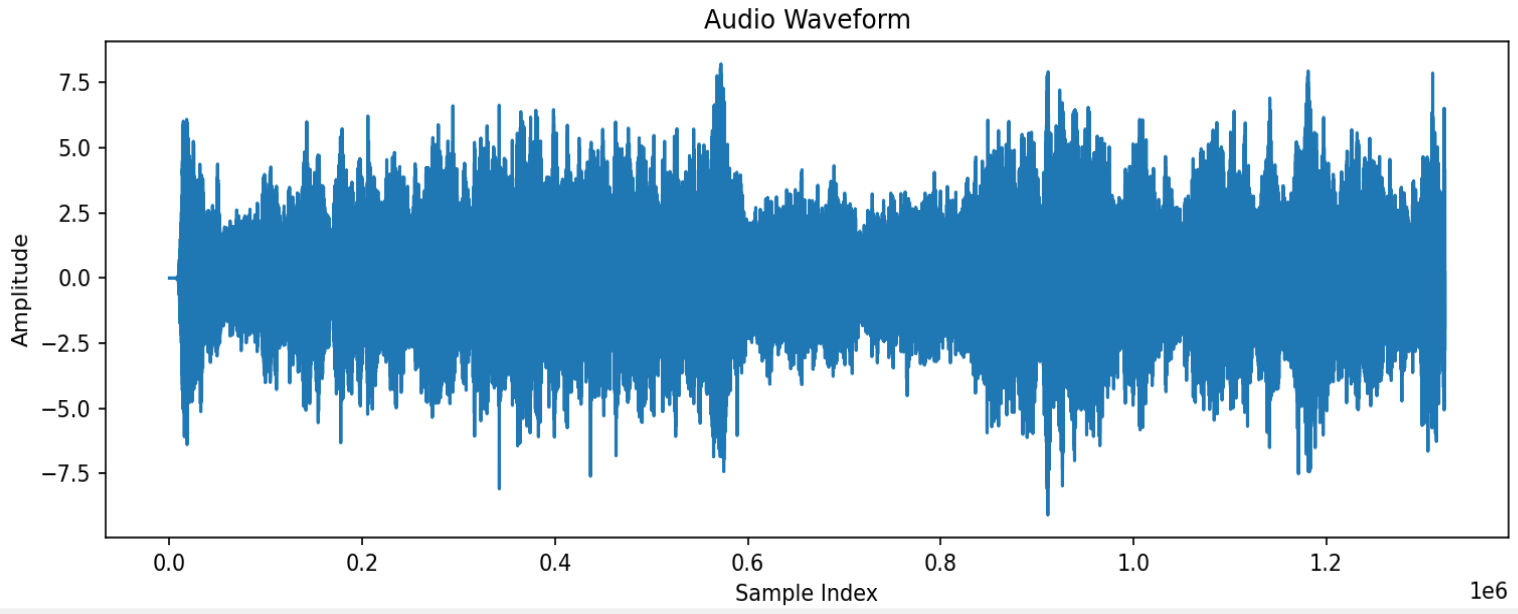



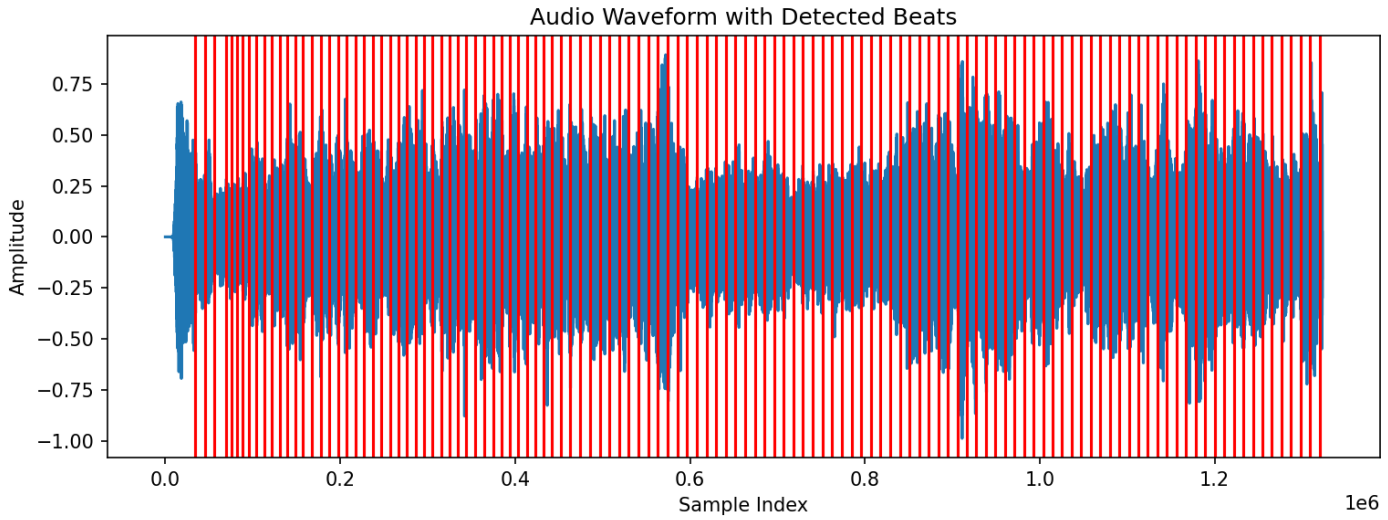
4. Aubio library for beat detection

FFT Flux formula

Spectral Flux method, which measures the difference in energy between consecutive short-time spectral frames.

$$x_n \xrightarrow{\text{window+FFT}} X_k \xrightarrow{\text{magnitude}} a_k$$

$$Flux(m) = \frac{\sum_k |a_k[m] - a_k[m-1]|}{\sum_k a_k[m] + a_k[m-1]}$$




```python
import numpy as np
import matplotlib.pyplot as plt
from pydub import AudioSegment
from aubio import source, tempo


def display_waveform_with_beats(file_path):
    audio = AudioSegment.from_file(file_path)

    # Convert audio data to numpy array
    audio_data = np.array(audio.get_array_of_samples())
    audio_data = audio_data / (2 ** 15)

    # Set up beat detection
    win_s = 512
    hop_s = win_s // 2
    samplerate = audio.frame_rate
    s = source(file_path, samplerate, hop_s)
    o = tempo("default", win_s, hop_s, samplerate)

    # Collect beat positions
    beats = []
    while True:
        samples, read = s()
        is_beat = o(samples)
        if is_beat:
            beats.append(o.get_last_s())
        if read < hop_s:
            break

    # Plot the audio data
    plt.figure(figsize=(12, 4))
    plt.plot(audio_data)

    # Plot the detected beats
    for beat in beats:
        plt.axvline(x=beat * samplerate, color='r', linestyle='-')

    plt.title('Audio Waveform with Detected Beats')
    plt.xlabel('Sample Index')
    plt.ylabel('Amplitude')
    plt.show()


# Replace "your_audio_file.mp3" with the path to your audio file
file_path = "StarWars60.wav"
display_waveform_with_beats(file_path)
```

5. Audio Stream