Academic Report: Pitch Scaling and Shifting Analysis in Audio Engineering Using Audacity

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1. Introduction

In audio engineering, **pitch scaling** and **pitch shifting** are widely used techniques to modify the pitch of an audio signal without altering its duration. These techniques play a vital role in music production, sound design, and speech processing. This report analyzes the effects of pitch scaling and shifting using Audacity by applying semitone adjustments of -6, +2, and +8 to an audio sample. The results focus on the changes in frequency content and the corresponding amplitude (dB) levels observed in the frequency plots.

2. Objective

The objective of this analysis is to understand how different semitone adjustments using Audacity affect both the frequency spectrum and the amplitude (dB) levels of an audio signal while maintaining its original duration. This study aims to explore the relationship between pitch modification and changes in audio power or loudness.

3. Methodology

To perform the analysis, the following steps were conducted using Audacity:

1. **Audio Signal Selection:**
    - An audio sample (e.g., a musical clip or vocal recording) was chosen to demonstrate the effects of pitch shifting.
2. **Pitch Shifting in Audacity:**
    - The pitch of the audio was shifted by -6, +2, and +8 semitones using Audacity's "Change Pitch" effect while keeping the original duration intact.
3. **Frequency and Amplitude Analysis:**
    - Audacity was used to generate spectrograms and frequency plots for each pitch-shifted version, focusing on changes in the frequency content and amplitude (dB) levels.

4. Tools Used

- **Audacity:** A free, open-source audio editor and recorder used for pitch shifting and frequency analysis.

5. Steps to Apply Pitch Shifting in Audacity

1. **Open the Audio File:**
    - Launch Audacity.
    - Go to `File > Open` and select the desired audio file.
2. **Select the Audio Portion:**
    - Use the selection tool (`F1`) to highlight the entire audio or a specific part for pitch shifting.
3. **Apply Pitch Shifting:**
    - Go to `Effect > Change Pitch...`

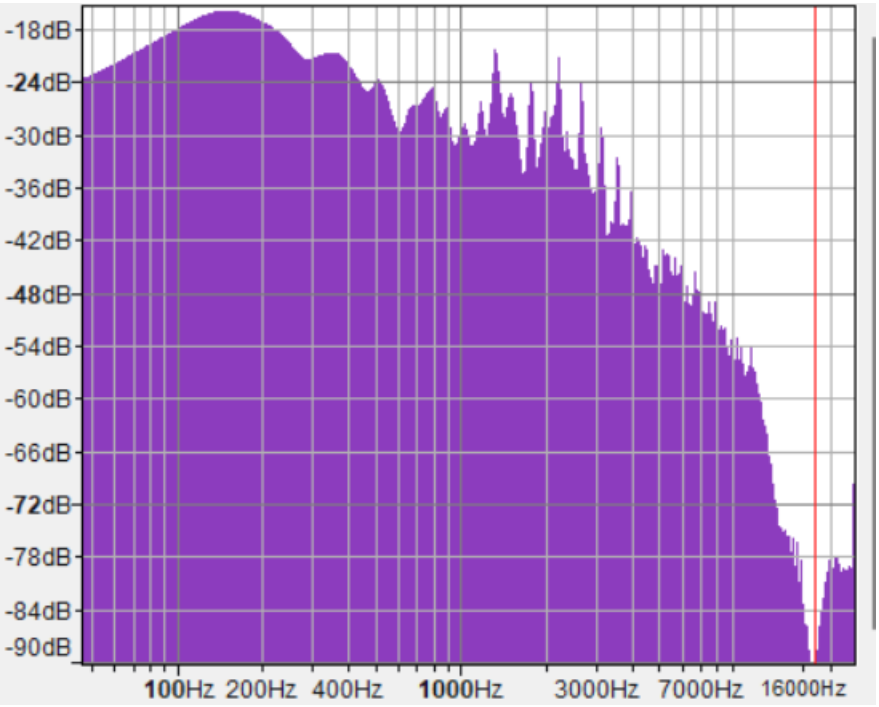
- In the "Change Pitch" dialog box:
  - Adjust the semitone shift by entering the desired values (-6, +2, and +8) in the "Semitones (half-steps)" field.
  - Ensure that the **"Maintain Tempo"** option is selected to keep the duration constant.
- Click `Preview` to listen to the effect and then `OK` to apply it.

4. **Generate Frequency and Amplitude Plots:**
   - To visualize the effects, go to `Analyze > Plot Spectrum...` after applying each pitch shift.
   - Capture the frequency plots and note the changes in dB values for each semitone adjustment.

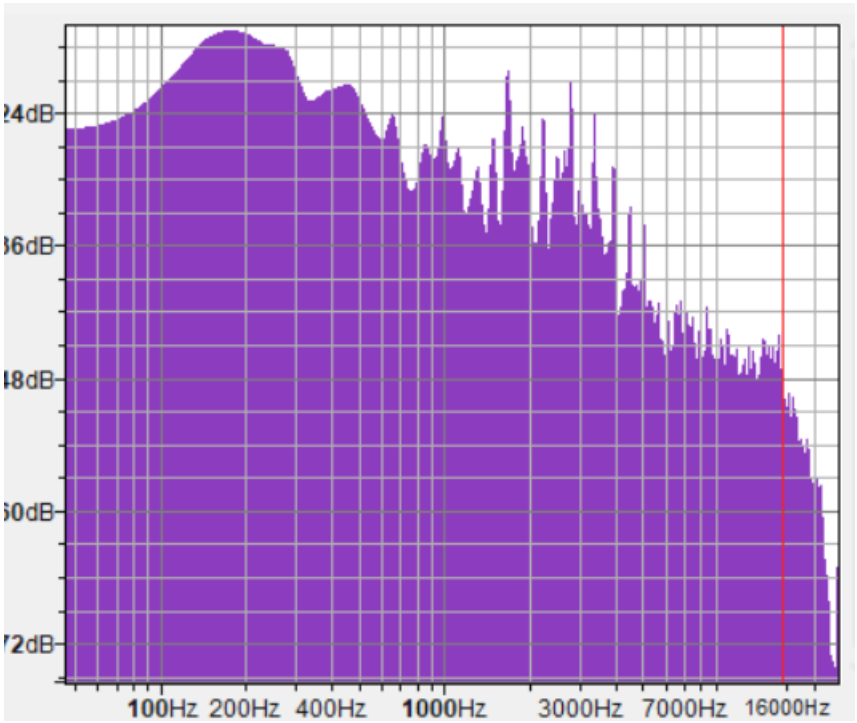
6. Results and Observations

The pitch shifting was performed with semitone values of -6, +2, and +8. The following observations were made based on the frequency plots and dB values:

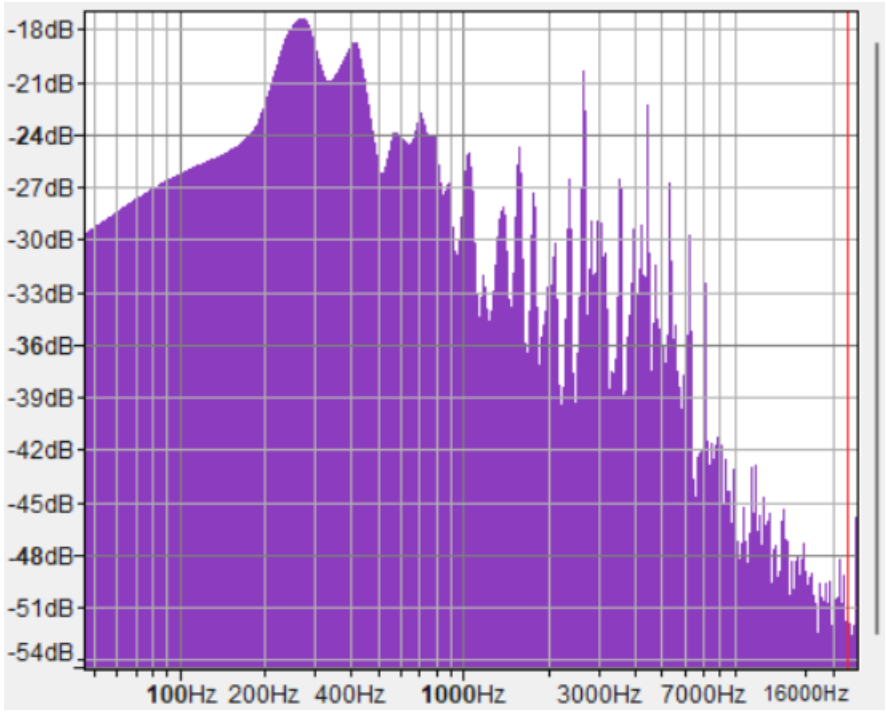
- **Pitch Shift by -6 Semitones:**
  - The frequency spectrum showed a downward shift, resulting in a lower pitch.
  - The overall amplitude (dB levels) remained relatively constant, with a slight reduction in the higher frequencies.



- **Pitch Shift by +2 Semitones:**
  - The frequency components shifted slightly upward, indicating a moderate increase in pitch.
  - A noticeable reduction in amplitude (dB) was observed across the frequency spectrum, particularly in the lower frequencies. The signal sounded slightly softer due to this reduction.



- **Pitch Shift by +8 Semitones:**
  - The frequency spectrum shifted significantly upward, resulting in a much higher pitch.
  - A more substantial reduction in amplitude (dB) was observed, especially in the lower and mid-frequency ranges. The audio signal appeared to lose some of its loudness as the pitch increased.



7. Analysis of Amplitude (dB) Reduction with Increased Pitch

- The analysis showed a correlation between increased pitch (positive semitone values) and a reduction in amplitude (dB levels):
    - **Why Does Amplitude (dB) Decrease?**
        - When the pitch is shifted upward, certain frequency components are stretched or compressed, affecting their energy distribution. Higher frequency components may have less energy, resulting in a reduction in dB values.
        - Auditory perception can also affect perceived loudness; higher pitches may be perceived as quieter, particularly if the audio system or human hearing has a lower sensitivity to those frequencies.

8. Conclusion

This analysis demonstrates that pitch shifting in Audacity not only modifies the frequency content of an audio signal but also affects its amplitude (dB levels). Key findings include:

- **Downward Pitch Shifting (-6 semitones):** Lowers the pitch with minimal impact on amplitude.
- **Moderate Upward Pitch Shifting (+2 semitones):** Slightly raises the pitch with a noticeable reduction in dB levels.
- **Significant Upward Pitch Shifting (+8 semitones):** Increases the pitch significantly but also reduces amplitude, making the signal sound quieter.

The results highlight the importance of considering both frequency and amplitude changes when applying pitch modifications, particularly in audio engineering applications where maintaining audio quality is crucial.