A Software-Based Pitch-Shifting Plugin for Modern Music Production

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The VST (Visual Studio Technology) and AU (Audio Units) plugin ecosystem greatly contributes to the music industry today. With the rise of digital audio workstations (DAWs) in the early 2000s, technology has become an integral part of music production and composition [2]. In particular, the electric guitar has long been associated with technological advancements in the industry. Engineers first harnessed the power of vacuum tubes to create the earliest electric guitar amplifiers, and later transitioned to transistor-based designs.

Today, traditional amps and effect pedals have been overtaken by virtual amplifiers and software-based effects plugins. Once-dominant traditional hardware companies are now competing with highly technical and lucrative software companies that specialize in music production software [2]. The purpose of this project is to design and implement a high-demand audio plugin for modern music production software.

The plugin in question is a pitch shifter, a widely used effect that digitally modifies an input signal in real time. Its core functionality is to increase or decrease the input signal's pitch by algorithmically altering every frequency component in a signal [1]. More importantly, it allows for a guitar player to quickly change the tuning of their guitar. This solves the common problem of a guitar player wanting to play a particular song in a certin tuning but their guitar does not support said tuning. Thus, the pitch shifter solves this problem by digitally modifying the guitar signal to the desired tuning before it reaches the amplifier. This is especially useful for guitarists who want to detune their instrument (tune the guitar to a lower pitch). Before detuning a guitar, one must consider a number of physical factors, such as the strings' gauge (thickness), the width of the nut, and the length and tension of the neck. If even one of these factors does not support a major detuning, the guitar cannot be safely or effectively retuned. A pitch shifter removes these physical limitations by solving the tuning problem through a purely software-based approach.

Although pitch-shifting effects already exist in both pedal and plugin form, their widespread use and high degree of customizability make this a worthwhile and technically meaningful project to pursue. The plugin will have a simple interface that abstracts much of the complicated signal-processing logic and mathematics that occur behind the scenes. The program's graphical user interface (GUI) will feature a dial that represents the semitone shift applied to the signal. Positive values will indicate an increase in pitch (uptuning), while negative values will indicate a decrease in pitch (detuning).

Additionally, the GUI will include a real-time visualizer of the incoming audio signal. This visualizer will display the signal in the frequency domain, with frequency measured in

hertz along the x-axis and magnitude along the y-axis. This will provide visual feedback in real-time showing how the pitch-shifting algorithm alters the guitar signal.

The core pitch-shifting algorithm will depend on several important parameters. According to Bowen Tang and Kiyofumi Tanaka in *An Efficient Real-Time Pitch Correction System via Field-Programmable Gate Array*, key factors include latency, floating-point arithmetic, and the choice between time-domain and frequency-domain analysis methods [3]. Notable algorithmic candidates for this project include the phase vocoder, constant-Q time-frequency analysis, and auto-correlation-based approaches.

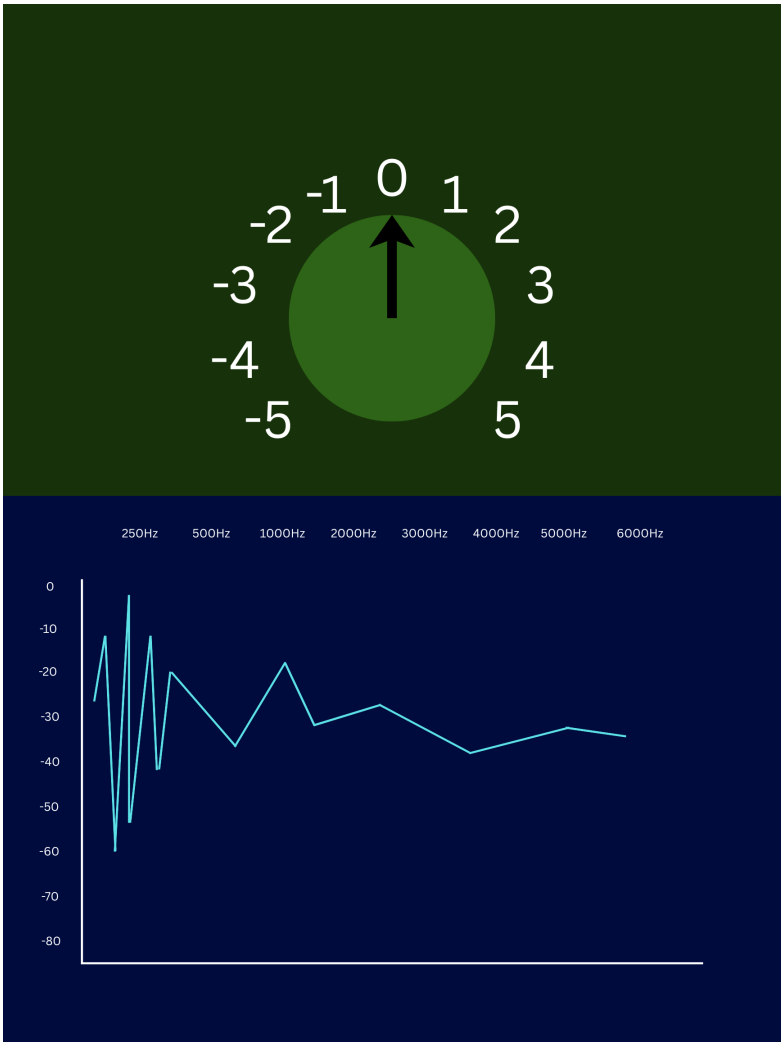

Figure 1: Proposed plugin design. It consists of a dial used to adjust the pitch of the input signal as well as a visualizer to view the modified signal in real time. The graph's units are Hertz on the y-axis and magnitude along the x-axis

Appendix

A concise list of features / user stories in the order in which they will be built. A few examples are below to demonstrate the expected scope and level of granularity; you will have more features than this.

- Default picture display on web application.
- On a button-click, user can separate the image into foreground and background.
- User can select a picture from their desktop.
- Selected picture displays on the web application.

References

[1] Rai, A., and Barkana, B. D. Analysis of three pitch-shifting algorithms for different musical instruments. In *2019 IEEE Long Island Systems, Applications and Technology Conference (LISAT)* (2019), IEEE, pp. 1–6.

[2] RaNa, M. R. H. The influence of technology on modern music production. *International Journal of Humanities and Information Technology 6*, 04 (2024), 19–25.

[3] Tang, B., and Tanaka, K. An efficient real-time pitch correction system via field-programmable gate array. In *Proceedings of the 2024 6th International Conference on Image, Video and Signal Processing* (2024), pp. 147–154.