Embedded System Final Project Proposal

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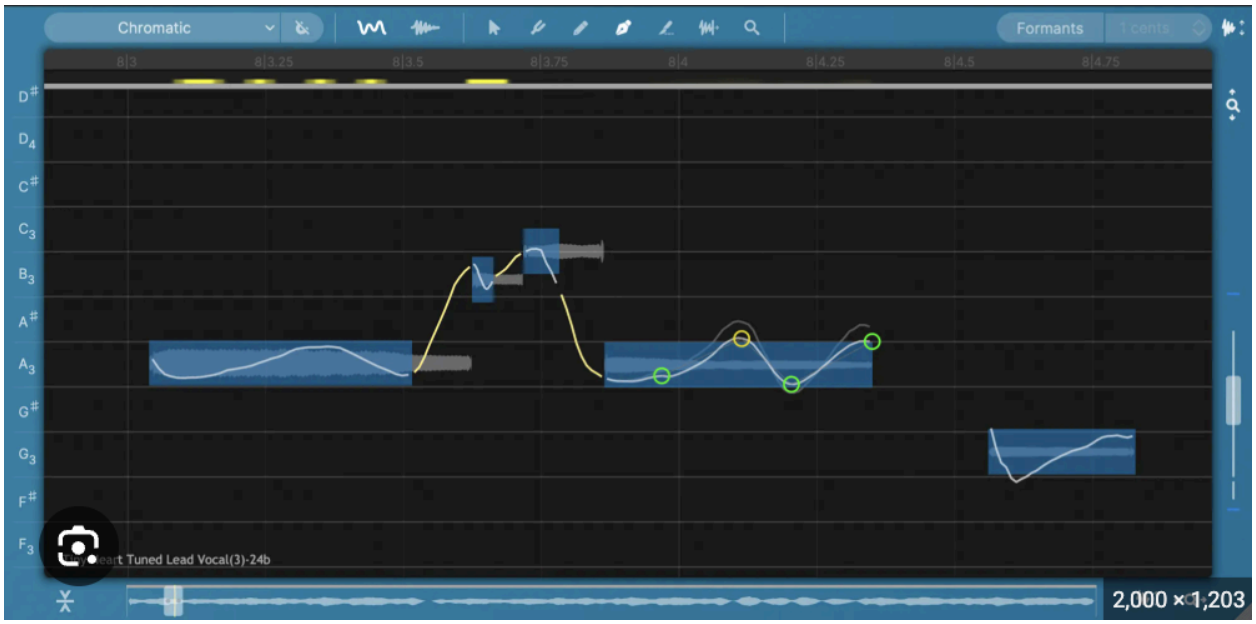
Overview:

We aim to develop a real-time audio processing system capable of detecting and shifting the pitch of audio signals captured from a microphone. . The system will capture audio from a microphone, process it for pitch detection and pitch shifting, and output the modified audio signal through a speaker.



Design:

Audio Input

- Microphone
- Analog to Digital converter
- Pre-processing
    - Decoupling capacitors

FPGA Processing by DE1 SOC Board

Signal Processing Core: the core algorithm of the entire program is real-time signal processing of input signals passed in. We will apply the input signal with multiple effects that will improve the audio quality. Below are some ideas that could be implemented.

Pitch detection: real-time detection of pitch.

Reverb: multiple sound-effect such as reverb and echo could improve the richness of the sound

Autotuning: This is the main part of our algorithm, which will process the input signal into the correct pitch to match the melody as much as possible. We have the following ideas to achieve:

1. Brute force method: manually match each pitch into a different pitch (direct frequency mapping)
2. Key matching: given the key of the song (G major, for example), match the pitch into the closest that corresponds to the key structure.

3. Machine Learning Algorithm: we can import some (or we can build ourselves) which learns the singer's habit to correct the input pitch into the pitch that makes the most sense given the audio overall.

Audio Output

A. Processed live sound output from the speaker

GUI: Graphic User Interface: to wrap up the core algorithm in signal processing, we will build a user interface that will handle user input from keyboard, mouse, and etc. Users will be able to generate input audio files (microphone recording, uploading pre-existing file), and then pick the processing they want to apply.

Additional Devices: (besides regular FPGA, C/C++, and System Verilog programming. Here are the additional devices we might potentially need for)

- Microphone & Speaker: devices that can process raw signal data to achieve real-time pitch matching.
- ADC & DAC converter: while the input and output signals are continuous. The core will need to process discrete signals. Therefore an ADC & DAC converter is needed to transform the format of the signals properly.

References:

1. https://github.com/shamim-hussain/fpga_fft_spectrum_analyzer
2. https://github.com/ashokfernandez/Yin-Pitch-Tracking
3. https://web.mit.edu/6.111/www/f2009/projects/cyrillan_Project_Final_Report.pdf
4. https://medium.com/axinc-ai/crepe-a-machine-learning-model-for-high-precision-pitch-estimation-8562d83d44a5