FPGAAAutotune

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What *is* Autotune?

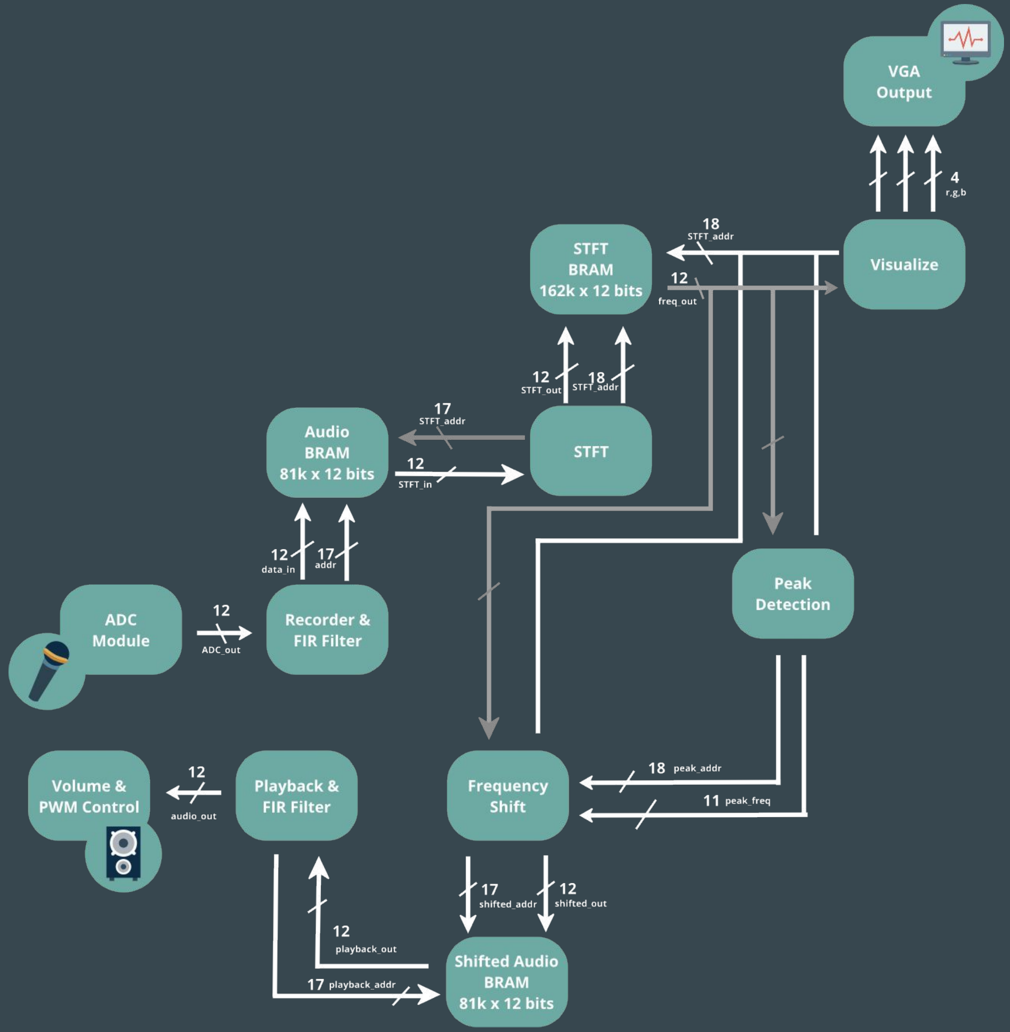
Methods for Autotune

<table>
<tr><th>Time Domain Method (TD-PSOLA)</th><th>Frequency Domain Method</th></tr>
<tr><td>1. Divide signal into chunks
2. Change frequency by shifting chunks:
  a. closer together = higher freq
  b. farther apart = lower freq
3. Reconstruct signal by adding chunks</td><td>1. Find STFT
2. Find frequency corresponding to each note
3. Shift by convolving original signal with two deltas at correct frequency</td></tr>
</table>

We're doing this in the FREQUENCY DOMAIN

- Most pitch correction implementations (including actual Auto-Tune) uses TD-PSOLA because it's simpler and computationally less intensive...
- So...why are we not doing this?

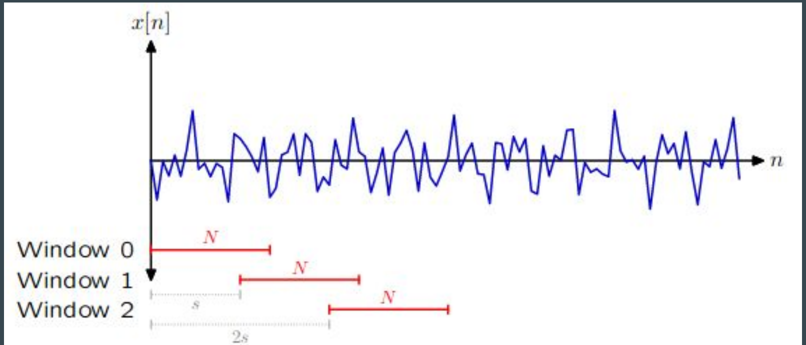
Overview



VGA Output
4
r,g,b
Visualize
18
STFT_addr
12
freq_out
STFT BRAM 162k x 12 bits
12
STFT_out
18
STFT_addr
STFT
17
STFT_addr
12
STFT_in
Audio BRAM 81k x 12 bits
12
data_in
17
addr
Recorder & FIR Filter
12
ADC_out
ADC Module
Peak Detection
18
peak_addr
11
peak_freq
Frequency Shift
17
shifted_addr
12
shifted_out
Shifted Audio BRAM 81k x 12 bits
12
playback_out
17
playback_addr
Playback & FIR Filter
12
audio_out
Volume & PWM Control

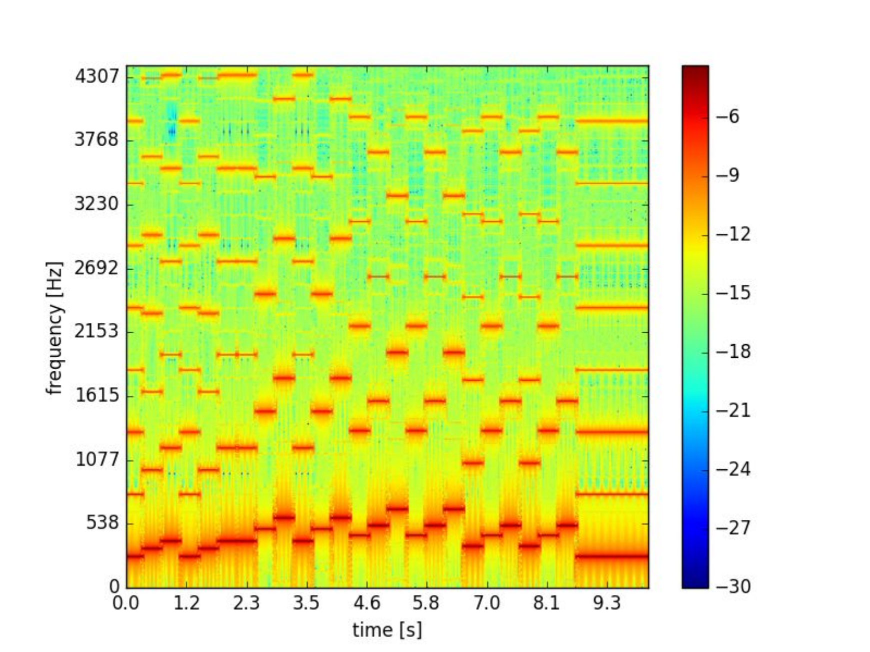
Short Time Fourier Transform (STFT)

1. Shift in 1024 samples
2. Apply Hann window
3. Calculate FFT using FFT Core
4. Calculate squared magnitude
5. Store squared magnitude in STFT BRAM
6. Go back a few addresses in audio BRAM
7. Shift in new 1024 samples
8. Repeat (step 2-6)



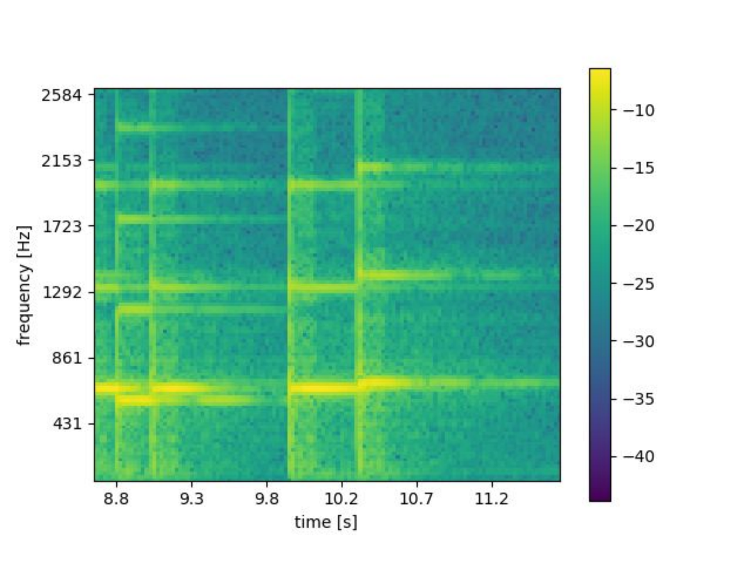
Visualization

1. Get the squared magnitudes from FFT BRAM
2. Map squared magnitude to colors (RGB)
3. Plot a spectrogram for the whole signal like →



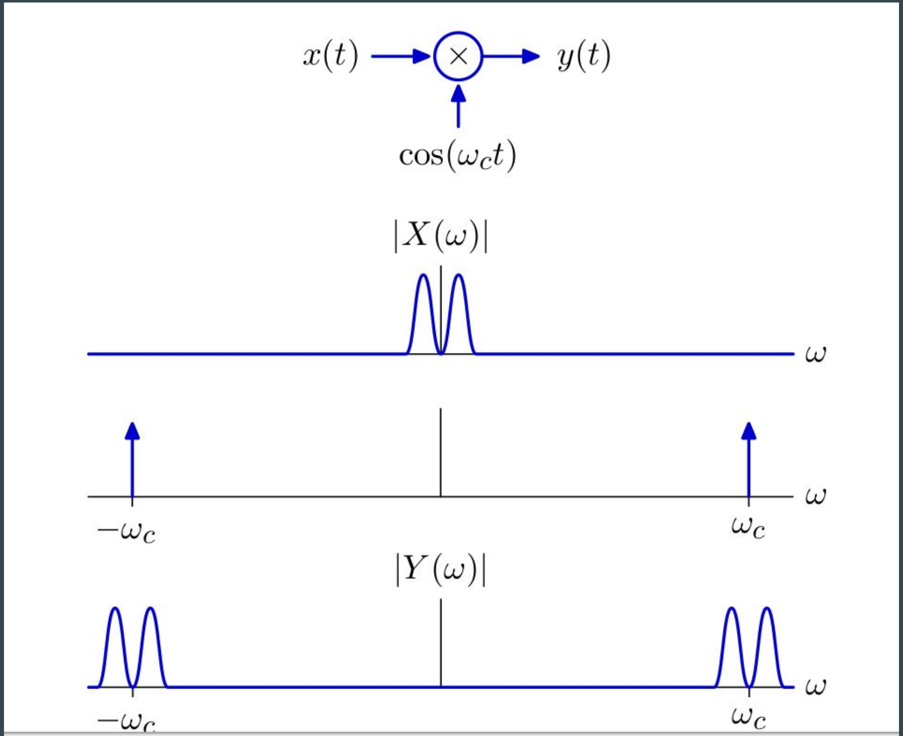
Peak Detection

1. Find the location of the notes
2. Find the freq that best represents that chunk
3. Use binary search on LUT to find closest “natural” frequency



Pitch Shifting

1. Construct a big filter that is: two deltas at desired frequency for each harmonic
2. Convolve filter with actual signal!
3. Take the IFFT and output it

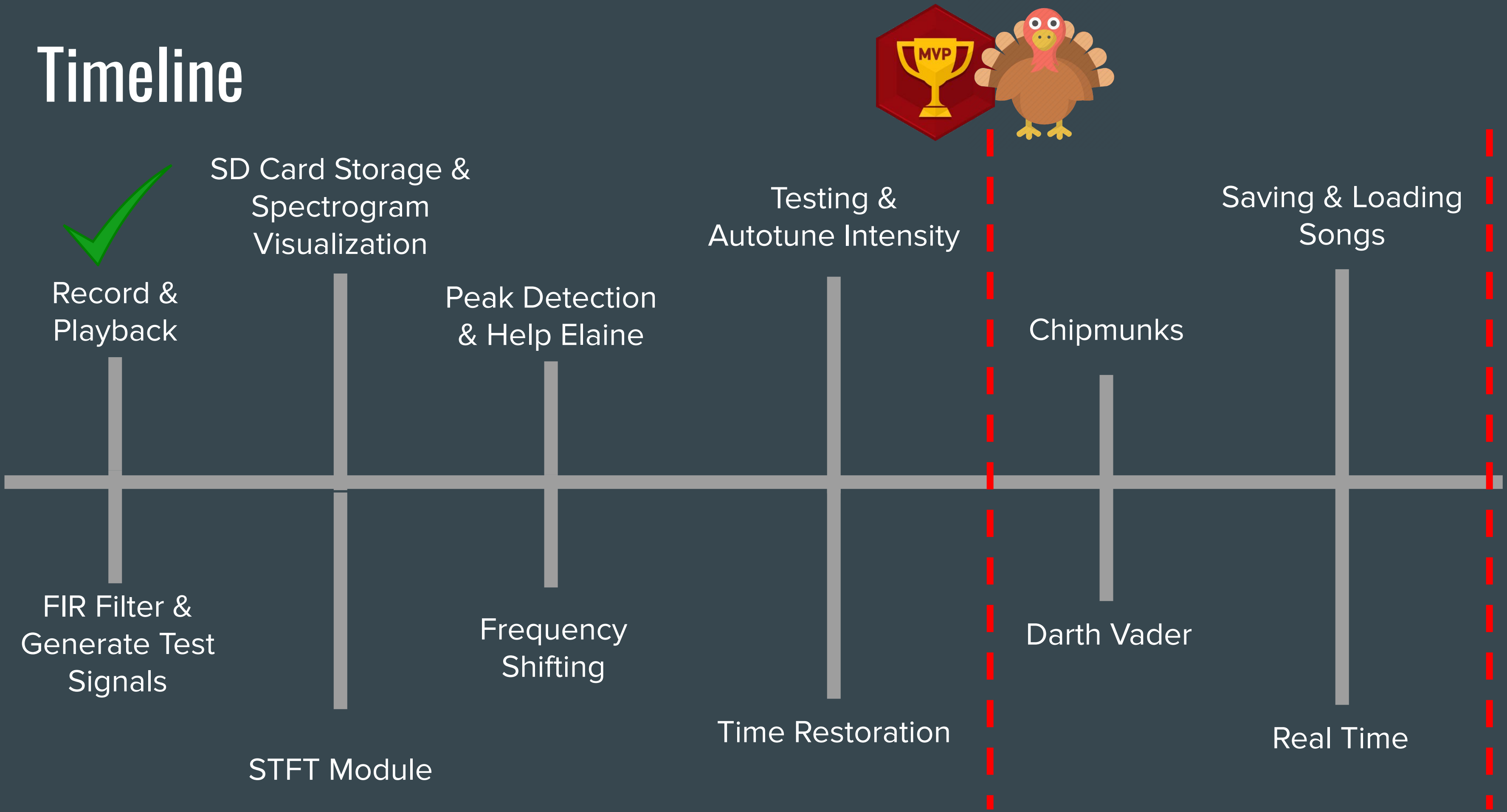


MVP +

Foreseeable Issues

- Memory (STFT, peak detection, pitch shifting, actual audio)
- Tuning sampling rates
- Tuning window sizes
- Timing (efficiency, modules synced properly)
- Restoring original durations

Timeline



Record & Playback
FIR Filter & Generate Test Signals
SD Card Storage & Spectrogram Visualization
STFT Module
Peak Detection & Help Elaine
Frequency Shifting
Testing & Autotune Intensity
Time Restoration
MVP
Chipmunks
Darth Vader
Saving & Loading Songs
Real Time

Questions?