Frequency Changes with Harmonic Bending

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Introduction

One of my friends first suggested that I study the technique of harmonica bending. I figured this would be cool to study because no one had ever done this before. I quickly learned why no one has done this before. There were many hoops I had to jump through to complete this project. When I began this project I had certain expectations such as the frequency changes remaining the same regardless of if an amplifier is used or not. I assumed that because the same note was being played the frequency should change by the same amount. However, this turned out to be false. I also expected the harmonic content concerning the amplitudes to remain constant. This once again proved to be false.

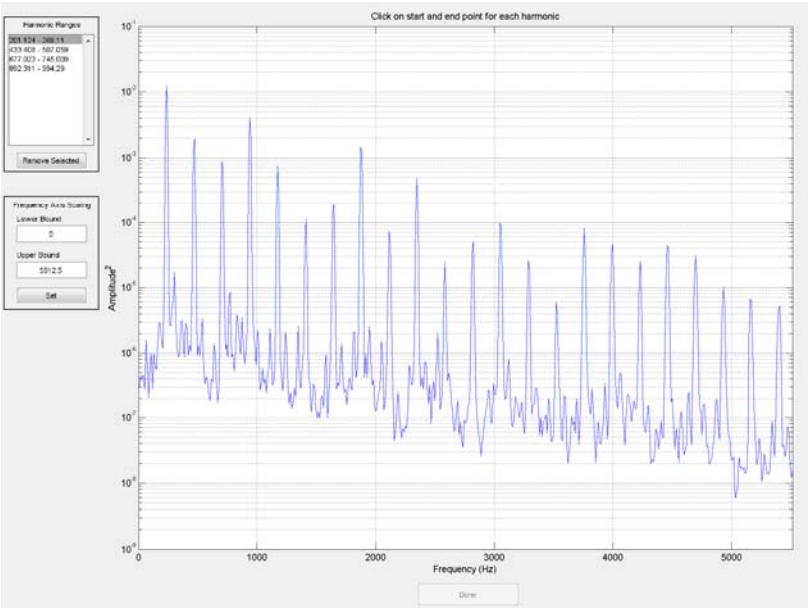
My friend, Erik Anderson, did the recordings back in February. These recordings were done off a harmonica in the key of A, four of these are used in my project.

I decided to use the MATLAB program Wave Analysis for this project. This program is able to analyze steady sounds. However, the technique of harmonica bending is inherently dynamic due to the pressure changes created by manipulating your tongue. Consequently, the pressure changes caused the program to crash. I had to find a way to work around this because the wave analysis program was the only program able to produce the necessary data.

In collision problems, frequently seen in classical mechanics, the focus is on what happens before and after the collision; rather than what happened during the actual collision. I decided to use a similar concept to work around the wave analysis program constantly crashing. I wanted to focus on what happened before and after the bend in order to compare the bends done with and without the use of an amplifier.

Procedure

I broke each recording into two sections; one before the bend and one after the bend. For each section I began by clipping the wave form into a piece that was between 1 and 1.5 seconds long. Next, I selected the first four harmonics to be analyzed.



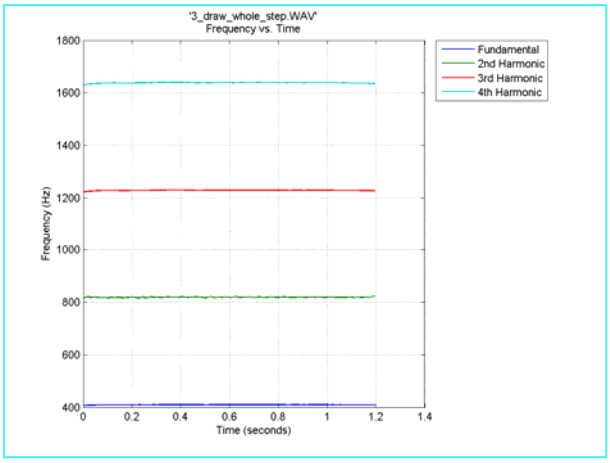
The wave analysis program then produced graphs regarding the harmonic amplitudes, the amplitude vs. time, the frequency vs. time, the absolute phase vs. time, the average relative phase phasor diagram, and the relative phase vs. time. For this project I was most concerned with the frequency vs. time and the harmonic amplitude graphs. These two graphs provided the most information, and they also looked the nicest; there were few jumps in the graphs.

Frequency vs. Time Graphs

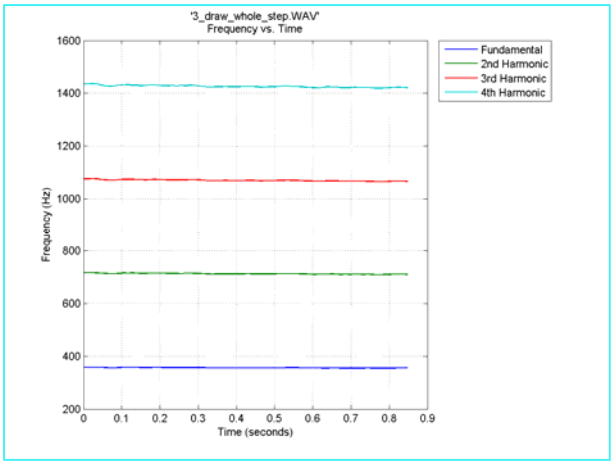
The frequency vs. time graphs showed the changes of frequency that occur as the result of the bending of the notes. In order to do this I approximated the value of the frequency for each of the four harmonics for the data done before and after the bend. Next I found the approximate difference between the values before and after the bend. I found that the frequency dropped every time for each harmonic. However, the amount they dropped was different depending on if an amplifier was used or not. The initial frequencies were the same for each harmonic regardless of if the amplifier was used; there was a larger drop that occurred after the bend with the amplifiers.

I assumed that the same notes were being played so the frequencies should change by the same amounts. It was shocking to see that the frequencies did not change by the same amount regardless of if an amplifier was used or not. In fact the frequencies dropped less when an amplifier was used. This lessened drop in frequency could be explained by the way amplifiers work to create a more pleasing sound.

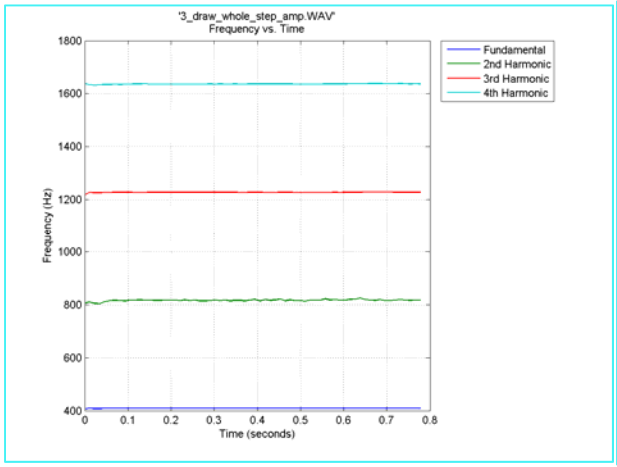
Draw Whole Step before the Bend



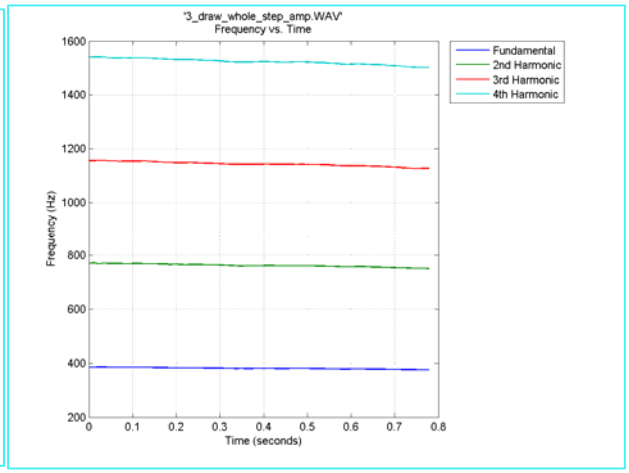
3 Draw Whole Step after the Bend



3 Draw Whole Step with Amp before the bend



3 Draw Whole Step with Amp after the bend



I found that when an amplifier was not used: the fundamental harmonic dropped by 40 Hz, the second harmonic dropped by 90 Hz, the third harmonic dropped by 150 Hz, and the fourth harmonic dropped by 200 Hz. However, when the amplifier was used: the fundamental harmonic dropped by 25 Hz, the second harmonic dropped by 40 Hz, the third harmonic dropped by 50 Hz, and the fourth harmonic dropped by 65 Hz. In this case the decrease was significantly less when an amplifier was used.

On average the frequency changes for each harmonic varied by:

	Without an Amp	With an Amp
Fundamental	-27 Hz	-19 Hz
2nd Harmonic	-70 Hz	-52 Hz
3rd Harmonic	-95 Hz	-60 Hz
4th Harmonic	-134 Hz	-91 Hz

From here we learn that there is significantly less of a frequency drop when the amplifier is used. The same notes are played even with the different frequency changes. This creates a more appealing sound.

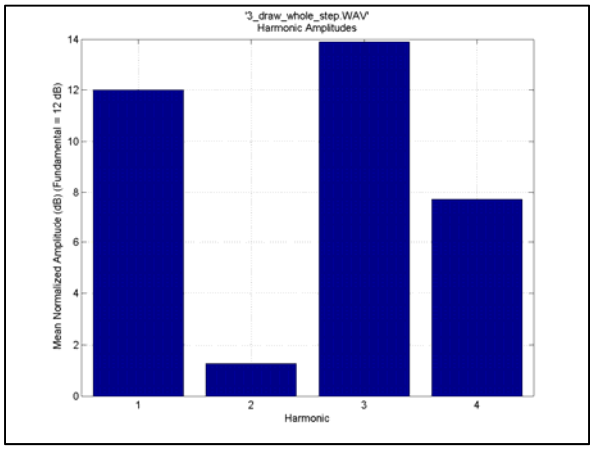
Harmonic Amplitudes Graphs

The harmonic amplitude graphs indicated which harmonics are played the loudest. I noticed that there was drastic changes between the graphs before and after the bend, as well as the graphs with and without the use of an amplifier. This made me decide to approximate the value of the Harmonic Amplitudes for the graph before and after the bend. Next I approximated the difference between these amplitudes to identify any possible patterns.

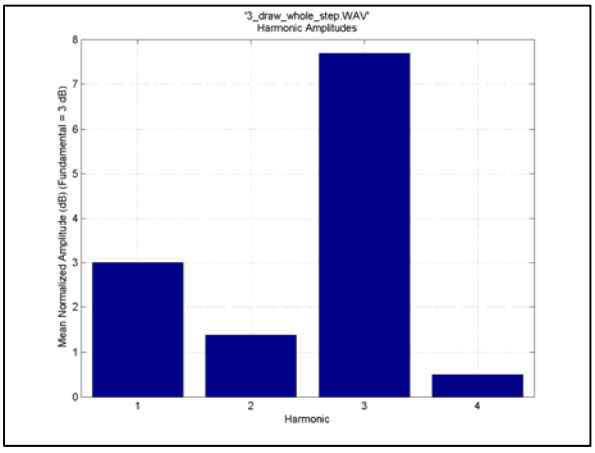
Earlier I stated that the use of an amplifier created a more appealing sound. This is seen from the harmonic content. The harmonic amplitudes drastically changed.

For example the 3 draw whole step:

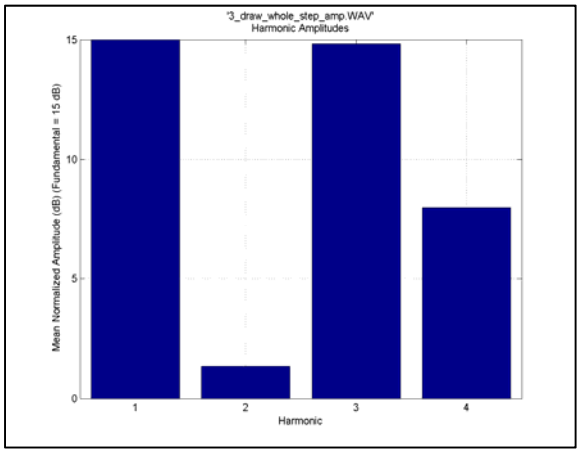
3 Draw Whole Step before the bend



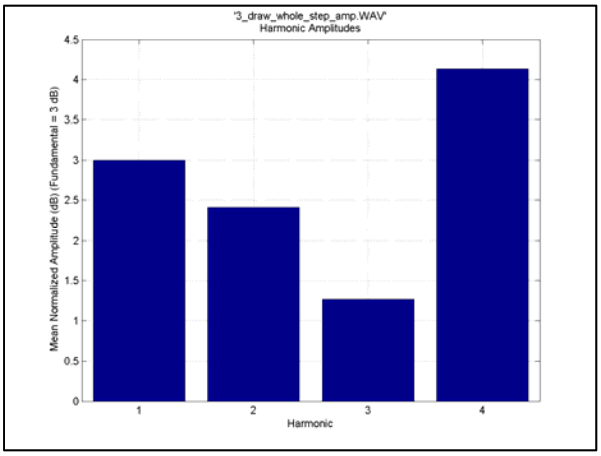
3 Draw Whole Step after the Bend



3 Draw Whole Step with Amp before the Bend



3 Draw Whole Step with Amp after the Bend



In this case the amplitude for the fundamental significantly drops. The fundamental starts at 12 dB without an amplifier and 15 dB with an amplifier. The fundamental then drops to 3 dB without an amplifier and 3 dB with an amplifier. These huge variations in harmonic amplitude creates a more appealing sound. They also appear to be almost random in terms of how much is dropped. In the graph above we can see that fourth harmonic goes from being loudly heard to not being heard at all.

Conclusion

I now realize why this data has never been collected before. This project tested my patience trying to get this program to run. I am one of those people who gets very easily frustrated when things do not work properly. However, I was able to find a way to work around it crashing. By treating the recordings like a collision problem I was able to visualize what I want to have happen easier. From this project I learned using an amplifier causes the frequency to drop less which creates the more appealing sound which is seen in the harmonic amplitudes.