Distortion Effect Implementation and Analysis by Digital Filters

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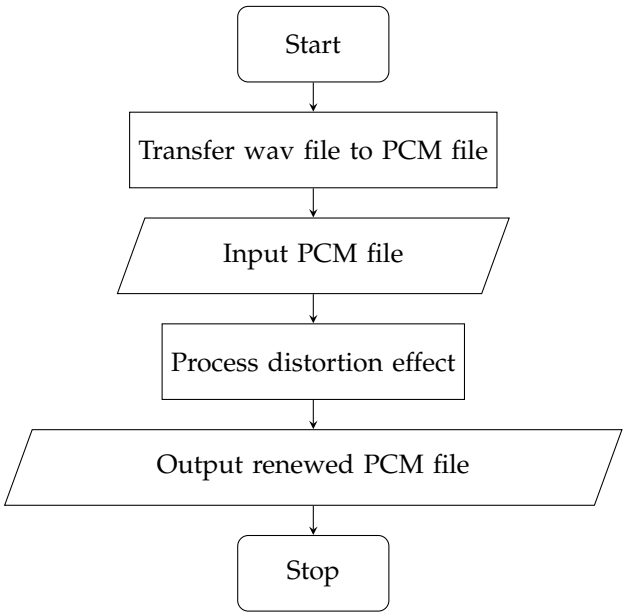
***Abstract*—Effects play a significant role in digital audio synthesis and mixing. Nowadays, in digital music making, most of producers more or less contain effects in their tracks. They are different kinds of effects such as dealy, normalization, flanging, reverb, tremolo and so on. This article adds distortion effect into Pulse-code modulation (PCM) files and analyzes results compared to the original signals.**

***Index Terms*—digital audio, effects, distortion, PCM.**

I. Overview of The Effect

Distortion is the alteration of the orignal shape. Distortion effect is always thought to be unnecessary and even should be avioded in signal processing for removing noise. However, in some other filed such as digital music, it has special charm in band. According to J. Pakarinen, guitar tube amplifier emulation has been an especially vibrant area of research with several commercial products.[1] Guitarists often combine eletric guitar with amplifier or effector to produce distortion effects deliberately to make intense sound which has an amazing result especially in live music.

II. Description of Implamentation



Due to distortion effect is mainly used in bass and electronic guitar or related digital music filed, this article adds distortion effects into two different kinds of guitar tracks which are two pieces of acoustic and electronic guitar records and lets them go through a basspass filter to distort the shape of signal respectively. Finally, comparing two results to orignal signals, we can analyze the outcomes of effects.

Algorithm 1 Distortion effect implementation by bandpass filter

Input: Read input PCM file (preprocess: transfer wav file to PCM file)

Output: Output the renewed PCM file by adding distortion effect

1: Transfer wav file to PCM file by deleting 44 bytes head data in wav file to get PCM file named "guitar.pcm"
2: Memory map PCM file into array which is int 16 format to make sure read & write are both able
3: Use function to add distortion effect through a bandpass filter with a threshold(10000) to distort the signal by clipping
4: Normalize the amptitude to the same level as input
5: Show the plot of result
6: **return** renewed PCM file

III. Results

Input files are two PCM files which are two records of acoustic guitar and electronic guitar respectively and output are two results of adding distortion effects into these original signals.

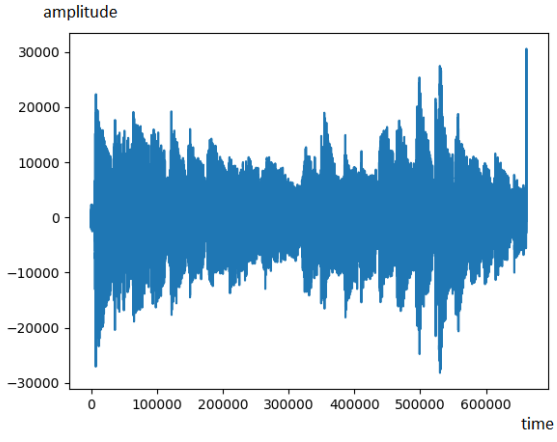


Fig. 1: orignal signal of acoustic guitar

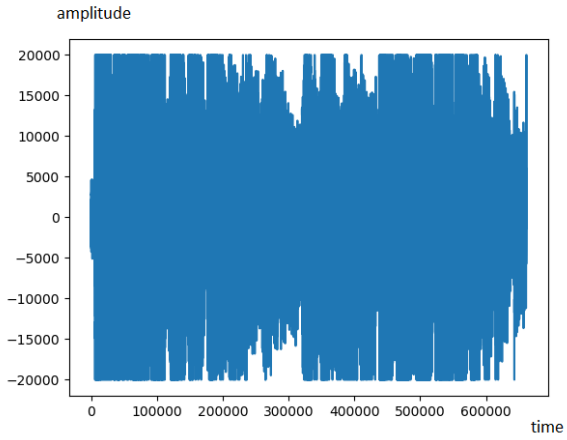


Fig. 2: add distortion effect to signal of acoustic guitar

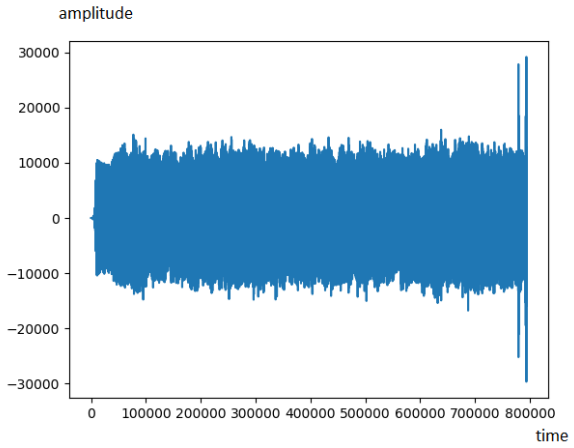


Fig. 3: orignal signal of electronic guitar

For the signal of acoustic guitar, the threshold is set to 10000 which is around the half of maximum amplitude of that signal. And the threshold for the signal of electronic guitar is set to 5000. The distortion filter is a bandpass filter by clipping the amplitude with the threshold value. In amplitude normalization process, it generally make values of all original amplitude double to match the orignal file for better comparision.

IV. Comparison

Using audacity to play above four PCM files, we can listen that the results are different. Adding distortion effect into acoustic guitar record seems not good which is like mixing noise into clear sound to make the quality of track bad. However, it has an amazing effect in electronic guitar record. Distortion effect in electronic guitar makes the tone more intense and increase the music atmosphere.

V. Summary

By using distortion function in audacity to process the orignal PCM files, it shows the same effect as above

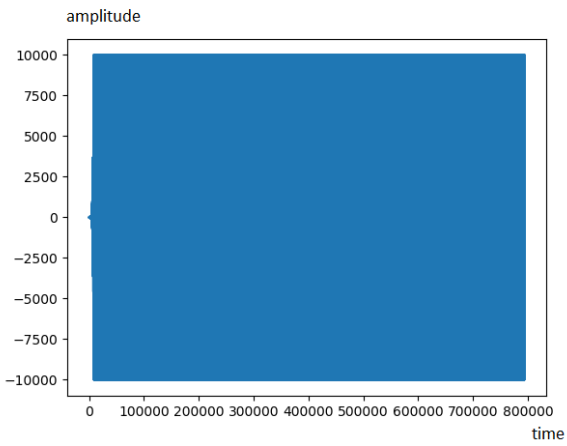


Fig. 4: add distortion effect to signal of electronic guitar

code and these two results are similar. In programming, the designed filter only makes changes to the amplitude of the signal which means amplitude distortion so the frequency spectrum is not changed. There are many other kinds of distortion such as frequency response distortion, phase distortion, group delay distortion and so on. In advance, a second order filter can be created by Marui and his teammates to provide more complete control over the parameters for electric guitars.[2]

VI. Conclusion

This article illustrates the amplitude distortion effect in two different records which are acoustic and electronic guitar tracks and compares the results both in signal and music. The effects are different for two different records. Distortion effect is good for electronic guitar and bad for acoustic guitar. Actually, all effects work in different fileds, some effects should be selected to use specially in digital audio.

References

[1] Pakarinen, J. (2010). Distortion analysis toolkit: a software tool for easy analysis of nonlinear audio systems. EURASIP Journal on Advances in Signal Processing, 2010, 1.

[2] Marui, A., & Martens, W. L. (2002, October). Multidimensional Perceptual Calibration for Distortion Effects Processing Software. In Audio Engineering Society Convention 113. Audio Engineering Society.

[3] https://www.swharden.com/wp/2009-06-19-reading-pcm-audio-with-python/

Appendix A
Python source code for wav to pcm transformation:

```
import os
import numpy as np
filename = "E_Guitar.wav"
f = open(filename,'r',encoding='latin-1')
f.seek(0)
f.read(44)
data = np.fromfile(f, dtype=np.int16)
```

```
data.tofile("E_Guitar.pcm")
```

APPENDIX B
PYTHON SOURCE CODE FOR ADDING DISTORTION EFFECT:

```
import numpy as np
import pylab

def distortion(data,threshold):
    for i in range(len(data)):
        if data[i] > threshold:
            data[i] = threshold
        if data[i] < -threshold:
            data[i] = -threshold
    return data

def amplitude_normalize(data):
    for i in range(len(data)):
        data[i]=2*data[i]
    return data

if __name__ == "__main__":
    filename = "E_Guitar.pcm"
    data = np.memmap(filename, dtype='h', mode='r+')
    data = distortion(data,5000)
    data = amplitude_normalize(data)
    pylab.plot(data)
    pylab.show()
```

APPENDIX C
PCM TEST FILES

link: https://github.com/XueGeChuiZi/CS-827
A3 PCM test files.zip contains:
Acoustic_Guitar.pcm
Acoustic_Guitar_Distortion.pcm
E_Guitar.pcm
E_Guitar_Distortion.pcm