SYNTH CHALLENGE 2022

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ABSTRACT

Nowadays, understanding how to create sounds and how to turn data into sounds is more relevant than ever. This challenge focus on synthesis of audio signals via two different tasks. This paper focus on the methods used to complete these two tasks and the results obtained.

Contents

1 Introduction

The aim of this challenge was to complete two assignments. The first assignment was about creating the sound of an electric car from a data set. The second assignment was about recreating the song **"Barcarolle"** from 'The Tales of Hoffman' by *Jacques Offenbach*.
Both of these assignment were completed using the computing platform MATLAB. The audio files created are joined to this report in the same folder. The methods used to create both of these two audio files and the results are given in the following parts.

2 Method

2.1 Bacarolle

Each note composing the "Barcarolle" is created by the MATLAB function "synth.m". The instruments used in this song are instruments number 1 and 49 of the instrument table which correspond respectively to "Acoustic Grand Piano" and "String Ensemble 1".

In order to create the different notes, midi files were used. After finding one midi note from a grand piano and another one from a violin on the Internet, these two notes were analyze using the Fourier transform in order to obtain the amplitudes of the fundamental and the harmonics for each of these two instruments. The amplitudes of the fundamental and the first 9 harmonics were then stored in a tab.

```
1  tab = zeros(128,10);
2  tab(1,:) = [0.0391 0.0178 0.00173 0.00136 0.000746 0.00189 0.00112
       0.000188 0.000284 0.00133];
3  tab(49,:) = [0.0318 0.0119 0.00757 0.00424 0.00508 0.00299 0.00150
       0.00205 0.00237 0.000277];
```

The basis of each note is a sinus signal:

```
1  y=amp*sin(2*freq*t);
```

This sinus is then tuned using the table created earlier in order for the note to sound like the correct instrument :

```
1  y=tab(synthtype,:)*amp*sin(2*pi*(1:length(tab(synthtype,:)))'*freq*t);
```

Finally, the envelope of the note is modified. The attack of each note is modified using the function $x \mapsto \alpha \log(1+x)$ and the decay following the function $x \mapsto \exp\left(\frac{-x}{\tau}\right)$. The duration of each note is used to calculate the constants α and τ.

2.2 Sound of an electric vehicle

The sound of the electric vehicle was created mostly based on it's speed. The speed of the vehicle is stored in the column nine of the table. In this table, we can observe that the speed is noisy, therefore the speed was smoothed using a window of 250 samples.

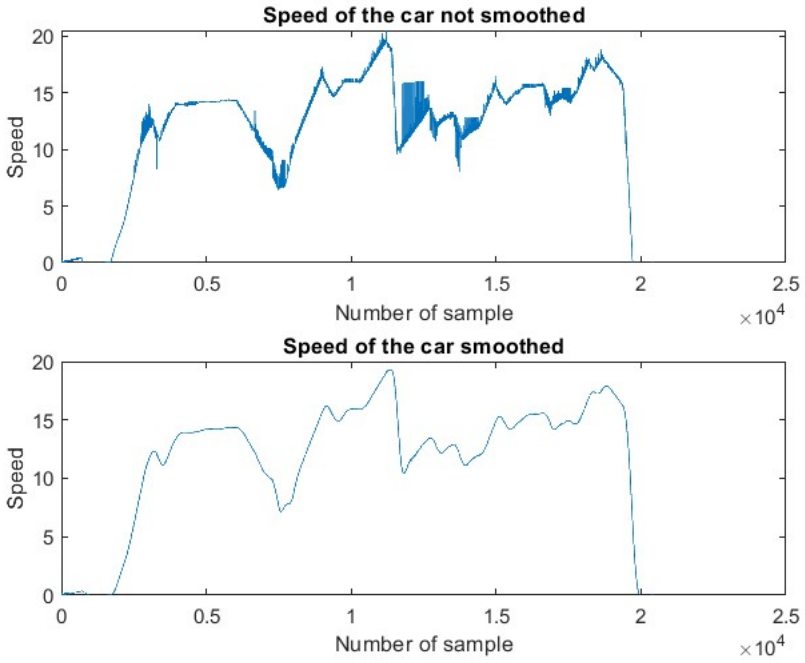

Figure 1: Speed of the car

The sound of the car was created from a simple sinus and was tuned following the sound of a bass guitar. The frequency of this sinus was then shifted according to the speed of the car : the higher the speed is, the higher the frequency of the sound is.

```
1     fa = fm + Sm(i)*c;
```

The sound was then modified according to the acceleration of the vehicle. The acceleration was calculated from the speed and smoothed with the same method used to smooth the speed.

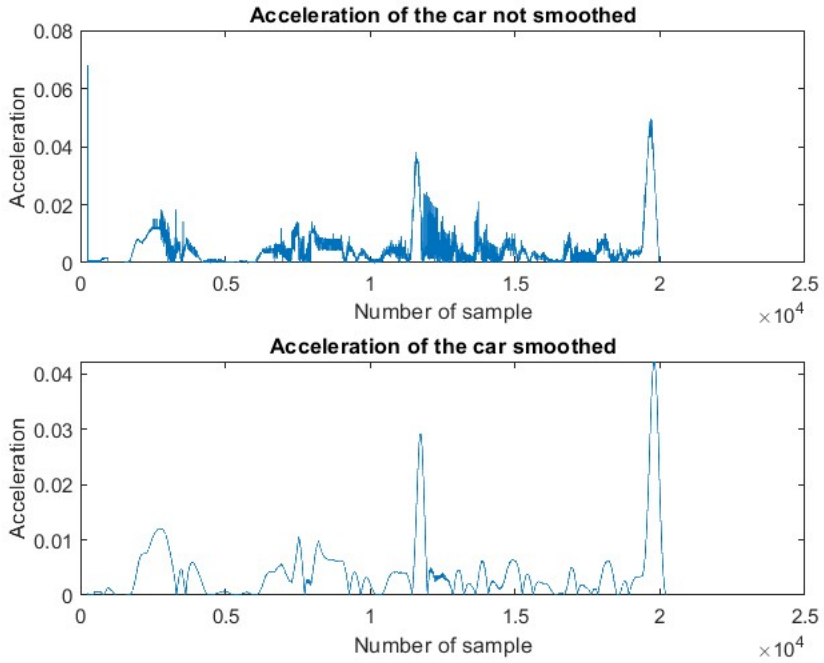

Figure 2: Acceleration of the car

The acceleration was used to modify the amplitude of the sound : the higher the acceleration is, the higher the amplitude is. In summary, the sound of the electric car has it's amplitude depending on the acceleration of the car and it's frequency on the speed of the car.

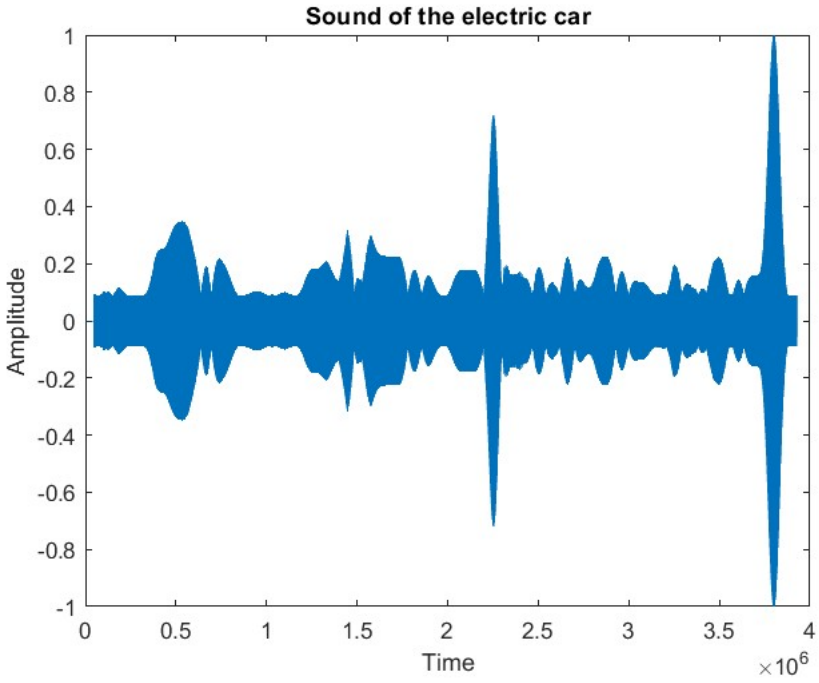

Figure 3: Final sound created

3 Results

3.1 Bacarolle

The song obtained is faithful to the original. The notes produced by the function "synth.m" are recognizable as notes produced by a piano or a violin. Furthermore, the envelope of the notes is designed in a way that all the notes are enjoyable to ear because the attack is not too steep and the decay is smooth.
On the other side, the song sound a bit minimalist mostly because only one violin act as a all string ensemble.
As far as I'm concerned, I'm satisfied with the result but some points can be improved. For example the sound of the string ensemble can be improved by adding more string instruments.

3.2 Sound of an electric vehicle

The main idea behind the sound synthesis of the electric car was the sonifcation of both the speed and the acceleration of the car. The amplitude of the sound synthesized depends on the acceleration while it's frequency depends on the speed, as a result this criteria is respected. Also when the car is going at a constant speed, the sound created is low and consequently, the driver is not annoyed by the sound.
On the other side, the sound produced can easily be annoying because of it's high pitch when the car is going fast. Also multiple elements could have been added to the sound for example to give information on the speed of the engine or the position of the steering wheel but I'm mostly satisfied with the sound obtained.

4 Conclusion

This challenge was a good exercise to understand the concept of audio synthesis and to use different methods of signal modification in concrete situations like music production or sonification of relevant data.