Synthesis of Audio Signals
Semestral project

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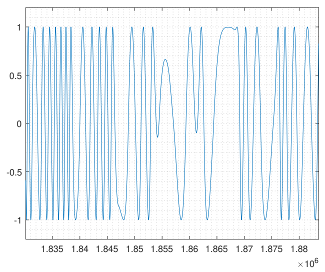
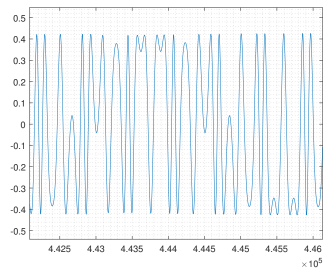
Sound of Škoda Superb

The first task of the project was to synthesise the sounds of an electric vehicle Škoda Superb. More specifically, create an audio track that would correspond to the provided control signals, which were generated with a car simulator. Around 80 signals were provided, which could be used for the synthesis. However, only some of them could potentially have a noticable effect on the sounds produced by a car, i.e. speed or engine rpm.
To solve this task, I used several control signals and applied synthesis techniques learnt during the course of B2M31SYN. Here is a list describing the individual sounds that were recreated and the methods that I used.

- **Engine RPM**. The vehicle should sound electric; that is why I tried to keep it quieter and not give it a lot of cracking noise that you would get from a fuel-based car. I used two simple waveforms: sawtooth(1/2) and sine, which I multiplied with each other. Both signals depend on an input frequency that was changing according to the control signal (a).
- **Speed**. For the speed sound I used frequency modulation (FM) with parameters: $fc = 60$Hz, $I_{max} = 5$ and $H = \frac{fm}{fc} = 1.2$. And used the speed control signal to modulate (AM) the result, so that the sound became louder when riding faster (b). Also, for both speed and rpm signals, I used the moving average to smooth out the signals.

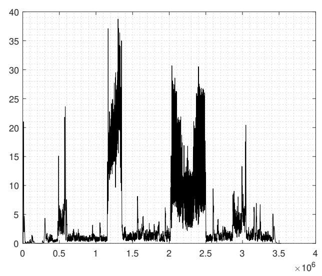


(a) Synthesised rpm wave.

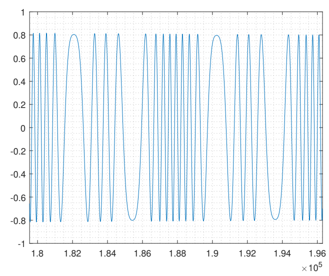


(b) Synthesised speed wave.

- **Speed bumps**. During the ride, the driver crosses two sections of the speed bump road, which shall produce distinct periodic sounds. To detect these road imperfections, I used the *pitch* control signal, which tells how much the vehicle is tilted forward. With the help of a simple *filter(1, [1 -0.999],...)* I filtered out the points when the bumps start (a). Then, I again used the frequency modulation with parameters: $fc = 27$Hz, $I_{max} = 18$ and $H = \frac{fm}{fc} = 0.2$ to get the sound. Finally, the exponential wrapping function was applied to the result (b).



(a) Filtered absolute pitch.



(b) Bumping signal.

- **Gear change**. The gear control signal is the simplest of all the previous ones. It is discrete and outputs an integer from -1 to 5. To obtain the timestamps of the changing gear, I used the *diff* function, which resulted in an easy-to-read signal, Figure 1. I tried to model this sound in a variety of ways and achieved something, but the final result did not satisfy me fully, and I decided that it would be better for the listener to listen to the audio without weird periodical clicking in his ears, and I removed changing gears from the final result.

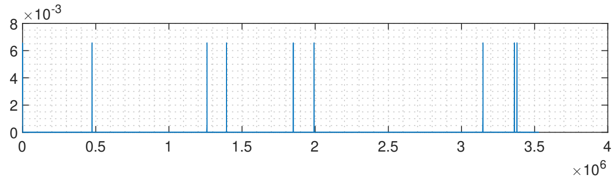


Figure 1: Changing the gear.

- **Traffic cone bump**. The last thing I did was add the bumping into the traffic cone sound at the end of the audio. As the test driver certainly knocked it off, it would be a missed opportunity to leave this sound out. I used the additive synthesis technique, Figure 3.

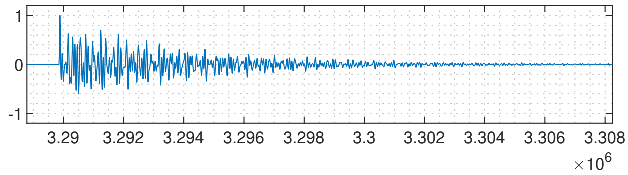


Figure 2: Cone bump.

Instrument synthesis of "Typewriter" by Leroy Anderson

The second part of the assignment was to create sounds for musical instruments used in the "Typewriter" by Leroy Anderson. To ensemble the whole composition, MATLAB functions were provided. They use *.mid files for that purpose. I modified the synth.m file to switch between 4 insrument tracks of the composition. Here are the instruments that I recreated.

- **Violin**. I chose the violin to be the first instrument in the song, as it is also used in musical concerts when performing this song. To create it, I used filter synthesis with an input of sawtooth signal with vibrato.

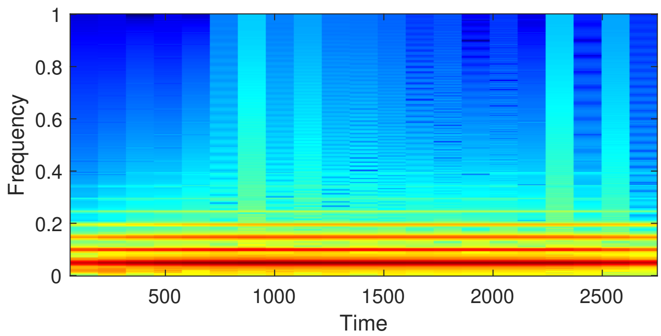
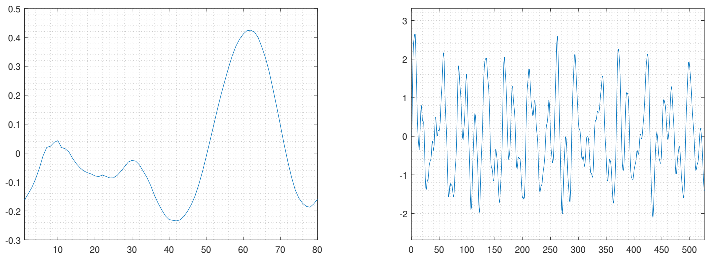


Figure 3: Violin note spectrogram.

- **Flute**. The flute is the second instrument I used in my work. Overall, in the composition, the second instrument has a lower tonality with which I quite liked the sound of the flute. To produce it, I used simple wavetable synthesis with linear interpolation on a sample from the website [1].

- **Glockenspiel**. To recreate this audio, I used the frequency modulation along with the additive synthesis technique. The sum of both sounds makes an interesting sound that I can see used when performing the "Typewriter". I also used an echoing effect on the sound from FM, which added a certain ringing sound.



(a) Flute wavetable sample.

(b) Glockenspiel wave.

- **Typewriter keyboard**. The main feature of this composition is the typewriter machine that produces percussive sounds that in turn are accompanied by other instruments. To achieve some degree of similarity to the actual keyboard, I used LPC synthesis, which took the error of the prediction as an input. I also added a fraction of simple white noise to the result, because it benefits the randomness of the sound, Figure 4.

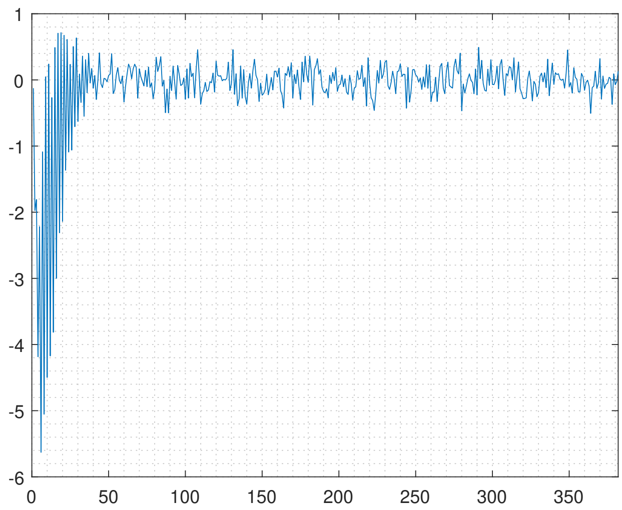


Figure 4: Typewriter key press sound.

References

[1] https://sami.fel.cvut.cz/syn/