POLITECNICO
MILANO 1863

MSc. Music and Acoustic Engineering

Musical Acoustics - A.Y. 2020/2021

HL4 – Radiance Estimation

Authors' IDs:
10743504, 10751919,

January 16, 2021

1 Signal observation

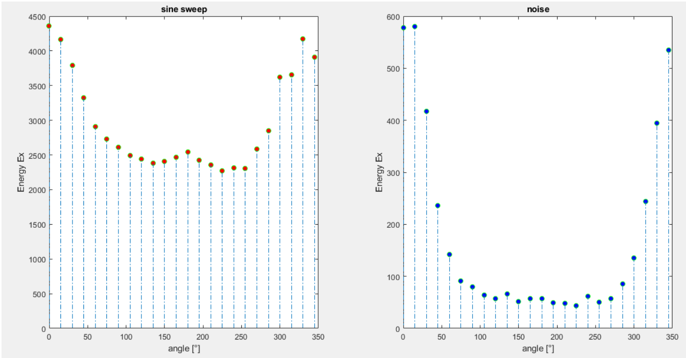

Figure 1: Energies of the recorded signals as functions of the angle of acquisition.

In `exercise1.m` we label the signals with the angle at which they were recorded and the related type of input. We then compute the energies of the signals with the function[1] shown in List. 1. The energies of the sine sweep signals are larger than those of the noise signals, which is expected since the sweep acquisitions were longer (10 vs. 3 seconds). Either way, Fig. 1 shows that the dependency on the angle is similar, as the energies are larger the closer we are to having the speaker pointed directly towards the microphone. Other specifics of the implementation, in this as in the other exercises, are explained in the comments of the Matlab scripts.

```
function [energy] = compute_energy(input)
  len = length(input);
  energy = 0;

  for i = 1:len
  energy = energy + abs(input(i))^2;
  end

end
```

Listing 1: compute_energy.m

2 Room reflection analysis using autocorrelation

	sweep	noise	both
TOA [ms]	3.00 ± 0.05	3.20 ± 0.06	3.1 ± 0.1
r [m]	1.03 ± 0.02	1.10 ± 0.02	1.07 ± 0.03

Table 1: Estimated time of arrival of the first reflection and microphone-reflector distance. From left to right, the averages over the sweep signals, the noise signals and over the entire set.

[1]This function has been added to the provided `Functions` folder.

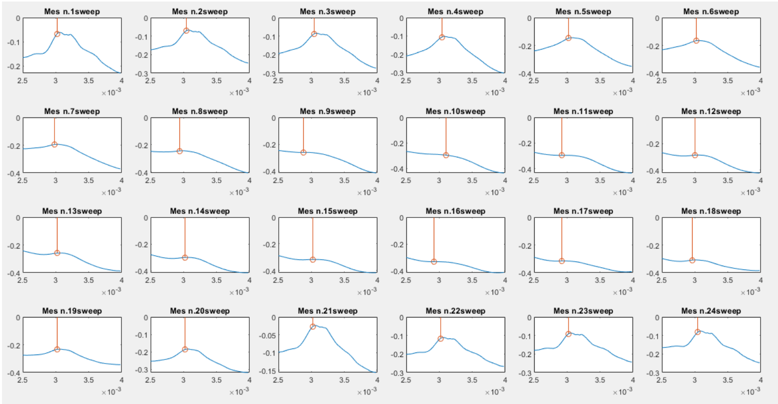

Figure 2: First peaks of the autocorrelation functions for the **sweep signals**. A small portion of the autocorrelation is shown and the stem highlights the position of the peak.

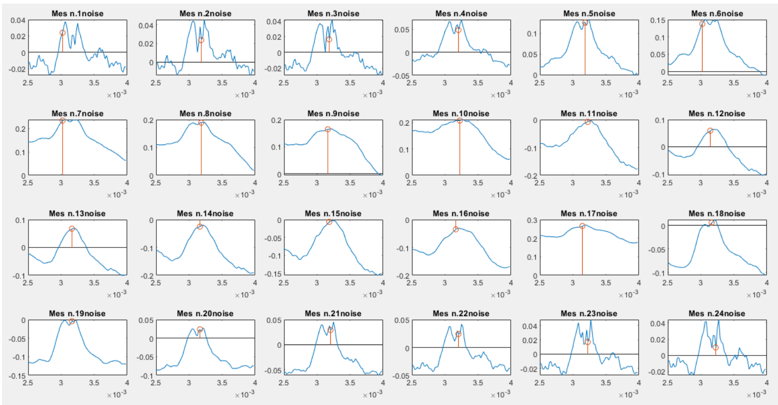

Figure 3: First peaks of the autocorrelation functions for the **noise signals**. A small portion of the autocorrelation is shown and the stem highlights the position of the peak.

In `exercise2.m` we estimate the first reflection time from the autocorrelation of the recorded signals. The autocorrelation is computed and then visualized in order to find the first reflection; a small portion (~ 2 ms) of the signal around the selected peak is then extracted and the library function `findpeaks` is run on it in order to estimate the exact location of the peak (see Figs. 2 and 3).

We then find an estimate of the time of arrival of the first reflection by taking the average and standard deviation of the locations of the peaks. We can use this value to compute the distance of the microphone from the reflector by multiplying them for the speed of sound c. The results are reported in Tab. 1. As we can see, both methods yield similar results with comparable precision. However, we can see that, comparing it to the sweep autocorrelations, the noise autocorrelations exhibit more high-frequency noise, which makes the estimation of the peak position slighlty less precise, especially close to 0°. On the other hand, though, if we zoom out (Fig. 4), we can see that the sweep autocorrelations

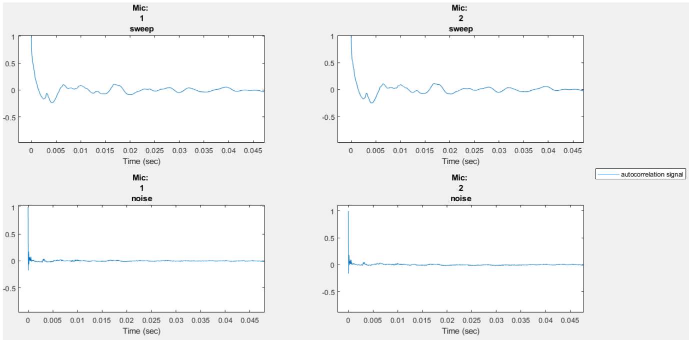

Figure 4: Autocorrelation for two sweep signals and two noise signals fro 0 to 45 ms.

are far noisier overall, due to the periodicity of the input signal, and this makes locating the first peak by visual inspection significantly harder, to the point that, without having the TOA estimated from the noise signals as a reference, it would be hard to tell whether the peak we are choosing is the correct one or merely an artifact. Overall, this leads us to conclude that measurements with the noise source are more reliable.