Exercise 1
This Exercise is about speaker localisation. On our website is a recording from an eight channel microphone array. Examine the different propagation delays between the individual micros by using cross correlation\(^1\). Make a good documentation about your experiments and evaluate your results. Try to find - if possible - the speaker direction.

Exercise 2
In the lecture was the FIR-filter \(y_n = \sum_{k=0}^{M} c_k x_{n-k}\) introduced. Where \(x\) is the input-signal and \(y\) is the output signal. The filter \(C\) with length \(M\) is described with the filter-coefficient \(c_k\). It is common to write: \(C[x] = y\).

\(A, B, C\) are filters with length \(M\). Proof the following equations for finite signals:

\(1P\) Subtask 2.1
\((A + B)[x] = (B + A)[x]\)

\(1P\) Subtask 2.2
\(((A + B) + C)[x] = (A + (B + C))[x]\)

\(1P\) Subtask 2.3
\(A * (B + C)[x] = (A * B)[x] + (A * C)[x]\)

Exercise 3
The aim of this exercise is to implement a box-filter for images.

\(2P\) Subtask 3.1
The boundary of the image is a problem for a box-filter. One can solve the problem by mirroring the image at the boundary. How far must the image be mirrored if you use a kernel \(K \in \mathbb{R}^{h \times k}\)?

Implement the function \texttt{imgmirror}, which mirrors a strip of width \(w\) at the bound of the matrix \(M \in \mathbb{R}^{n \times m}\). You should get an output matrix \(O \in \mathbb{R}^{n+2 \cdot w \times m+2 \cdot w}\)

\(^1\)Microdisplacement: 2cm; Matlab-function to readin audio-signals: “auread()”

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**Subtask 3.2**
Implement the function `boxfilter`, which filters the matrix $I_1 \in \mathbb{R}^{n \times m}$ with kernel $K \in \mathbb{K}^{h \times k}$. You should use your function `imgmirror` to handle the boundaries. The matrix $I_2 \in \mathbb{R}^{n \times m}$ is the output of your function.

$$I_2(i, j) = \sum_h \sum_k K(h, k)I_1(i - h, j - k)$$

(1)

What is the running time of your implementation?

**Subtask 3.3**
Use the functions you implemented to denoise an image. You should use the “mean-smooting”-kernel of the lecture. You can use your own image and add “salt and pepper” noise or use the image on our website.

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