1 Exercise

In the lecture you performed the derivation for a formula for the discrete first derivative of an image. Similarly to this derivation you can derive a formula for the second derivative given below.

\[ L(f(x, y)) := \frac{\delta^2 f(x, y)}{\delta^2 x} + \frac{\delta^2 f(x, y)}{\delta^2 y} \]  \quad (1)

1.1 (5P) Subtask

Perform the derivation for the second derivative and rewrite it in form of a 3x3 matrix. For what could a matrix of this form be used when applied as a filter kernel?

2 Exercise

In this exercise, you will implement a simple feature extraction. It is highly recommended to use Matlab’s “help” command.

2.1 (1P) Subtask

Please find and use the file “sound1.wav” (or “sound1.au”) on the course website. Use “wavread(...)” (or “auread(...)” respectively) to read in the file. Now make use of “sound(...)” to properly play the soundfile in Matlab.

2.2 (1P) Subtask

You have already heard about Pre-emphasis in the lecture. Now you should implement a function pred(s) which applies it to the audiostream s\(^1\). Use the following definition:

\[ f'_n = f_n - \alpha \cdot f_{n-1} \quad \text{with} \quad \alpha = 0.95 \]  \quad (2)

Which kind of filter is it? Is it a low- or high-pass filter?

\(^1\)You can use the Matlab function filter().
2.3 (2P) Subtask

Implement the Matlab function:

\[
\text{function } M = \text{windowing}(s, \text{shift}, \text{width})
\]

which applies a Hamming\(^2\) window to signal segments (called frames) of width \(w\). How many frames \(f_n\) can be produced from a signal of length \(k\) assuming a shift of \(sh\) samples and a frame width of \(w\). \(M\) will be a Matrix \(\in \mathbb{R}^{f_n \times w}\).

2.4 (2P) Subtask

Use the function of 2.2 and apply it to the audiostream. Assume a shift of 10ms and a width of 25ms to create a spectrogram. Therefore use the Matlab function \text{spectrogram}(...)\) in combination with \text{view}(90, -90).

\text{(It is necessary to compute the amount of samples for the shift and width!)}

Show the original audiostream and your spectrogram; Can you see some similarities?

2.5 (1P) Subtask

You will find the Matlab function \text{mel} on our course website. Use it, assuming the following parameters:

\[
fl = 133.33334Hz \quad (3)
fh = 6855.4976Hz \quad (4)
fft\_size = 1024 \quad (5)
fs = 16kHz \quad (6)
L = 24 \quad (7)
fmel = 1125Hz \quad (8)
\]

The result will be a Matrix \(W \in \mathbb{R}^{L \times \text{fft\_size}/2}\) containing one filter per row. Plot the whole filterbank within the range 0:100.

\(^2\)You can use the Matlab Funktion \text{hamming}.