Lecture "Digital Signal Processing"

Prof. Dr. D. Klakow, summer term 2019

Tutorial 5

Submission deadline: 03.06.2019, 10:15

Submission Instructions:

You have one week to solve the tutorials.

The code should be well structured and documented. Do not use any Matlab-Toolbox or Python external libraries if not mentioned that you could use it.

- You are allowed to hand in your solutions in groups of two students.
- The theoretical part should be submitted before the lecture.
- For the practical tasks please submit files via the email address
  Tutorial 1: dsp.tutorial1@gmail.com Tutorial 2: dsp.tutorial2@gmail.com
- The subject of the letter should be [**DSP TUTORIAL X**]. **X** is the tutorial/assignment number.
- Rename and pack the main directory:
  Ex05_matriculationnumber1_matriculationnumber2.zip.

The directory that you pack and submit should contain the following files:

- code files and supporting files (library, image and sound etc.);
- file "answers.pdf" which contains answers to the questions appearing in the exercise sheet;
- file "README" that contains an information on all team members:
  name
  matriculation number
  email address.
- Note: If you use Jupyter Notebook, you don't have to submit "answers.pdf".You can write your theoretical answer in the markdown area

1 (6P)Exercise

1.1 (4P) Subtask

Two Gaussian distributions $X_1 \hookrightarrow \mathcal{N}(X_1|\mu_1, \sigma_1^2)$ and $X_2 \hookrightarrow \mathcal{N}(X_2|\mu_2, \sigma_2^2)$ are given.

1. Prove that multiplication of them results in Gaussian. Mention the resultant mean and variance
2. Prove that convolution of them also results in Gaussian. Also mention the resultant mean and variance.

1.2 (2 P) Subtask

Given that $\vec{y} = \mathbf{A}\vec{x} + \vec{e}$
Prove that minimizing trace of error covariance $Tr(\mathbf{E}[\vec{e}\vec{e}^T])$ is maximizing $\mathbf{P}(y|x)$

2 (3P)Exercise

Here you will implement a sensitivity pattern of microphone array for following configuration. Folloing information are given:

1. Location of signal sources in 3D coordinate is $s_1 = Rcos(\theta)sin(\phi)$, $s_2 = Rsin(\theta)sin(phi)$ and $s_3 = Rcos(\phi)$. By varying the ϕ and θ you can simulate many source from different direction.
2. The specific location of source which you want to listen is [0,1,1]
3. Sound wave is $sin(\omega t)$ and velocity is 330 and $\omega = 3500$
4. All of your microphones are omnidirectional and number of microphones is 5
5. Location of microphones $x = [[m1_x, m1_y, m1_z], [m2_x, m2_y, m2_z], [m3_x, m3_y, m3_z], ..]$

Write a function *directivity(x, θ, ϕ)* that calculate the power ratio (All mics' power : Single mic's Power) and returns that value. Use $R = 1$.

2.1 (1 P) Subtask

Use *directivity(x, θ, ϕ)* to find the power ratio in the given specific direction for a square based pyramid configuration(5 microphones are situated in five corners, $x = [[0, 0, 1], [1, 0, 0], [0, 1, 0], [0, -1, 0], [-1, 0, 0]]$).Hint: $theta = [0 : 2\pi]$ and $\phi = [0 : \pi]$ and use their all combinations. Keep this values for later use.

2.2 (1 P) Subtask

Now plot all the values you found in previous subtask in 3D polar coordinate using all combination of θ and ϕ. Note: You can convert the values from polar coordinate to Cartesian 3D coordinate and then plot in 3D