

Problem Set 1

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1. Problem

Describe how you could obtain the spectrogram of a vector using only a matrix product. How will that matrix look like? What are the equations that describe the whole operation?

Answer

Suppose that the signal we got is $\vec{x}^T = [x_1 \ x_2 \ \dots \ x_n]$. And the Fourier transform matrix is F .

Suppose that we choose N and set the overlap be 50%. So, in order to use Fourier matrix to multiple the signal, we need to change $\vec{x}^T = [x_1 \ x_2 \ \dots \ x_n]$ into the format of X .

$$X = \begin{bmatrix} x_1 & x_{1+N/2*1} & x_{1+N/2*2} & \dots & x_m \\ x_2 & x_{2+N/2*1} & x_{3+N/2*2} & \dots & x_{m+1} \\ \vdots & \vdots & \vdots & \vdots & \\ x_N & x_{N+N/2*1} & x_{N+N/2*2} & \dots & x_n \end{bmatrix}$$

So, the final spectrogram will be:

$$S = F * X$$

Now, the problem is how to get X from \vec{x} . Here, however, I don't think only one matrix product can change \vec{x} into X . Rather, we need

$$X = A * \vec{x} * B$$

where A is $N * m$, B is $1 * m$.

So, the final expression for S will be:

$$S = F * A * \vec{x} * B$$