Optimization

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Overview

Question 4.1

Show using e(n) = d(n) - $W^T(n)X(n)$ that

$$\nabla_{\mathrm{W(n)}} e^2(n) = \frac{\partial e^2(n)}{\partial W(n)} = -2X(n)d(n) + 2X(n)X^T(n)W(n)$$

Solution

We can write $\mathrm{e}^2(n) = e(n)^T e(n)$
using above equation,

$$\mathrm{e}^2(n) = (d(n) - \mathrm{W}^T(n)X(n))^T \cdot (d(n) - \mathrm{W}^T(n)X(n))$$

As d(n) is scalar,
$\mathrm{e}^2(n) =$
$d^2(n) - (X^T(n)W(n))d(n) - (W^T(n)X(n))d(n) + X^T(n)W(n)W^T(n)X(n)$

Differentiating w.r.t W(n) we get,

$$\nabla_{\mathrm{W(n)}} e^2(n) = -2X(n)d(n) + X(n)(W^T(n)X(n))$$

or

$$\nabla_{\mathrm{W(n)}} e^2(n) = -2X(n)d(n) + X(n)(X^T(n)W(n))$$

Question 4.2

Use the gradient descent method to obtain algorithm for solving

$$\min_{\mathrm{W(n)}} \mathrm{e}^2(n)$$

Solution

From gradient descent algorithm we know

W(n+1) = W(n) - $\mu \cdot (\nabla_{\mathrm{W(n)}} e^2(n))$

Using $\nabla_{\mathrm{W(n)}} e^2(n)$ value from previous question we get,

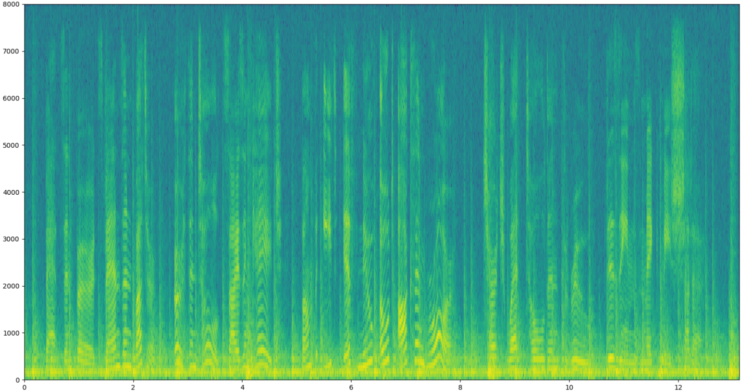
W(n+1) = W(n) + $\mu \cdot X(n)(d(n) - X^T(n)W(n))$
or
W(n+1) = W(n) + $\mu \cdot X(n) \cdot e(n)$

Question 4.3

Write a program to suppress X(n) in d(n).

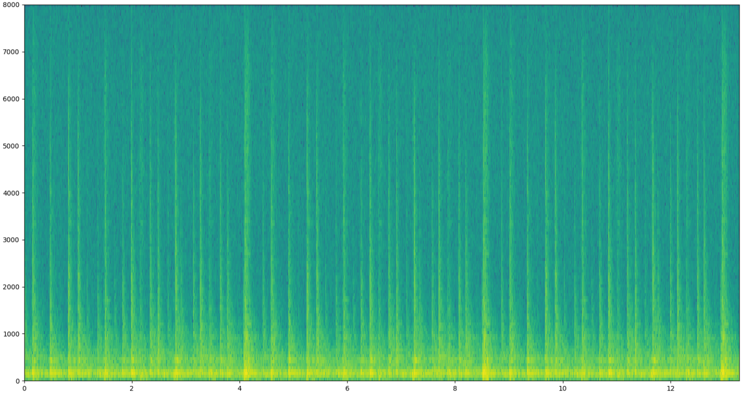
Solution

Signal with noise spectogram



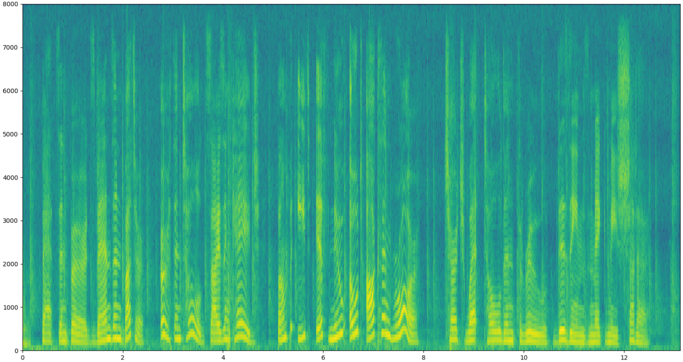
Solution

Spectogram of noise



Solution

Output signal spectogram



Code at https://github.com/gadepall/adsp/blob/master/lms/LMS_NC_SPEECH.py

The End