ELG5377 Adaptive Signal Processing

Simulation of LMS-Based Algorithms

Introduction

- We have seen the development of the algorithms for LMS, NLMS and Affine Projection Adaptive Filters
- We wish to compare the three algorithms in terms of performance (convergence, misadjustment, mean square deviation).

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Equalization example

- Equalizer
  - $u(n) = d(n) - 0.2d(n-1) + v(n)$
    - Where
    - $d(n)$ is independent binary data (equiprobable +1 or -1)
    - $v(n)$ is White Gaussian noise with 0 mean and variance 0.1
    - We want to use a three tap transversal filter to equalize the input. The desired output is $d(n)$.

Wiener Solution

- We can show that

$$\mathbf{R} = \begin{bmatrix} 1.14 & -0.2 & 0 \\ -0.2 & 1.14 & -0.2 \\ 0 & -0.2 & 1.14 \end{bmatrix}$$

$$\mathbf{p} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}, \quad \mathbf{w}_o = \mathbf{R}^{-1}\mathbf{p} = \begin{bmatrix} 0.906 \\ 0.164 \\ 0.029 \end{bmatrix}, \quad J_{\min} = 0.0994$$

Practical considerations

- λ_{max} = 1.423, μ_{max} (LMS) = 1.41
- In NLMS, μ = μ(LMS)/tr(**R**), therefore μ_{max} = 1.41*tr(**R**) = 1.41*3.42 = 4.82.
- We will use $\mu = 0.1\mu_{max}$ in all cases.
- NLMS is special case of AP.
- For AP, we'll use $N = 2$. Since we are using two vectors, we'll divide μ of NLMS by 2.

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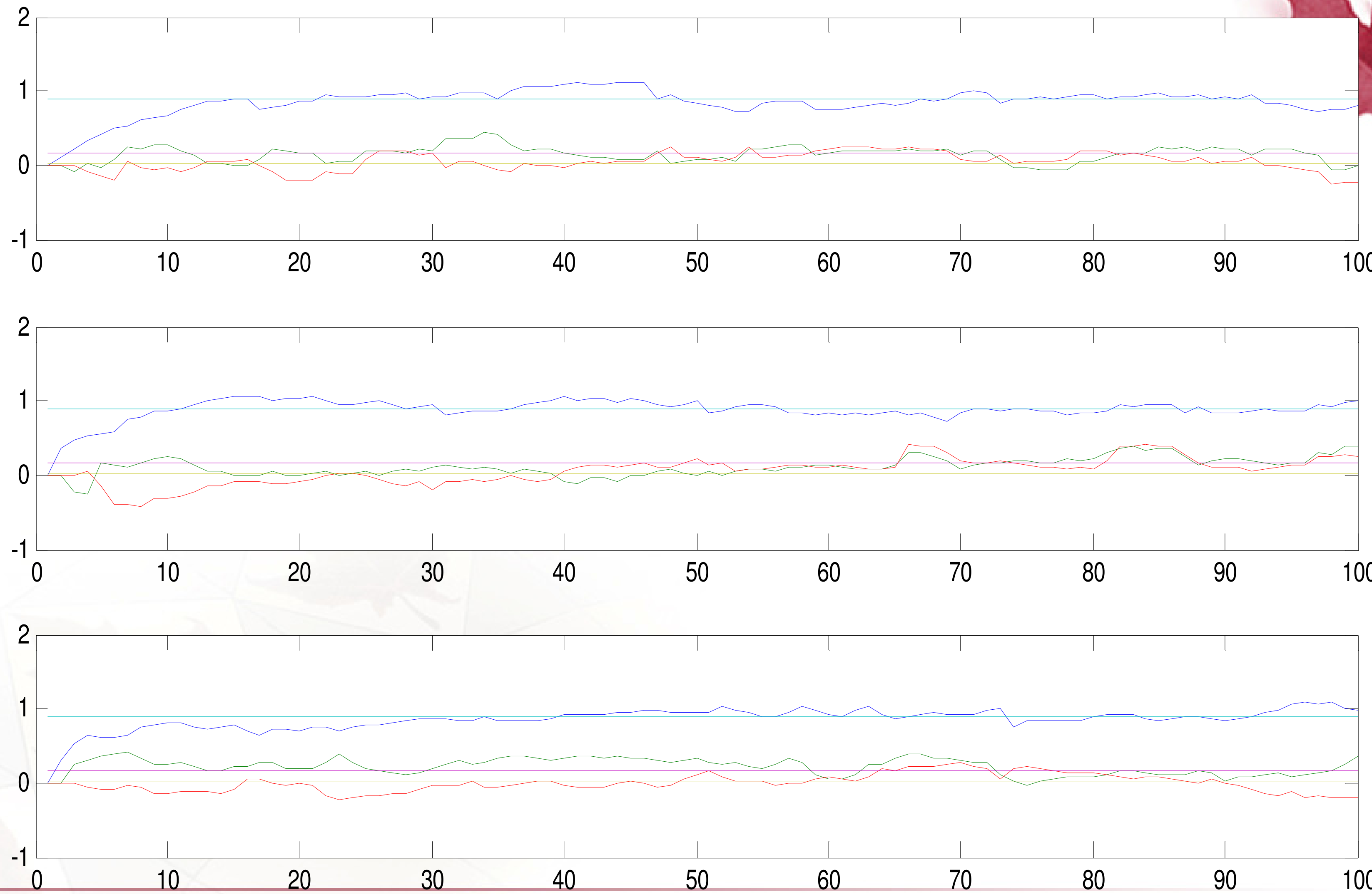
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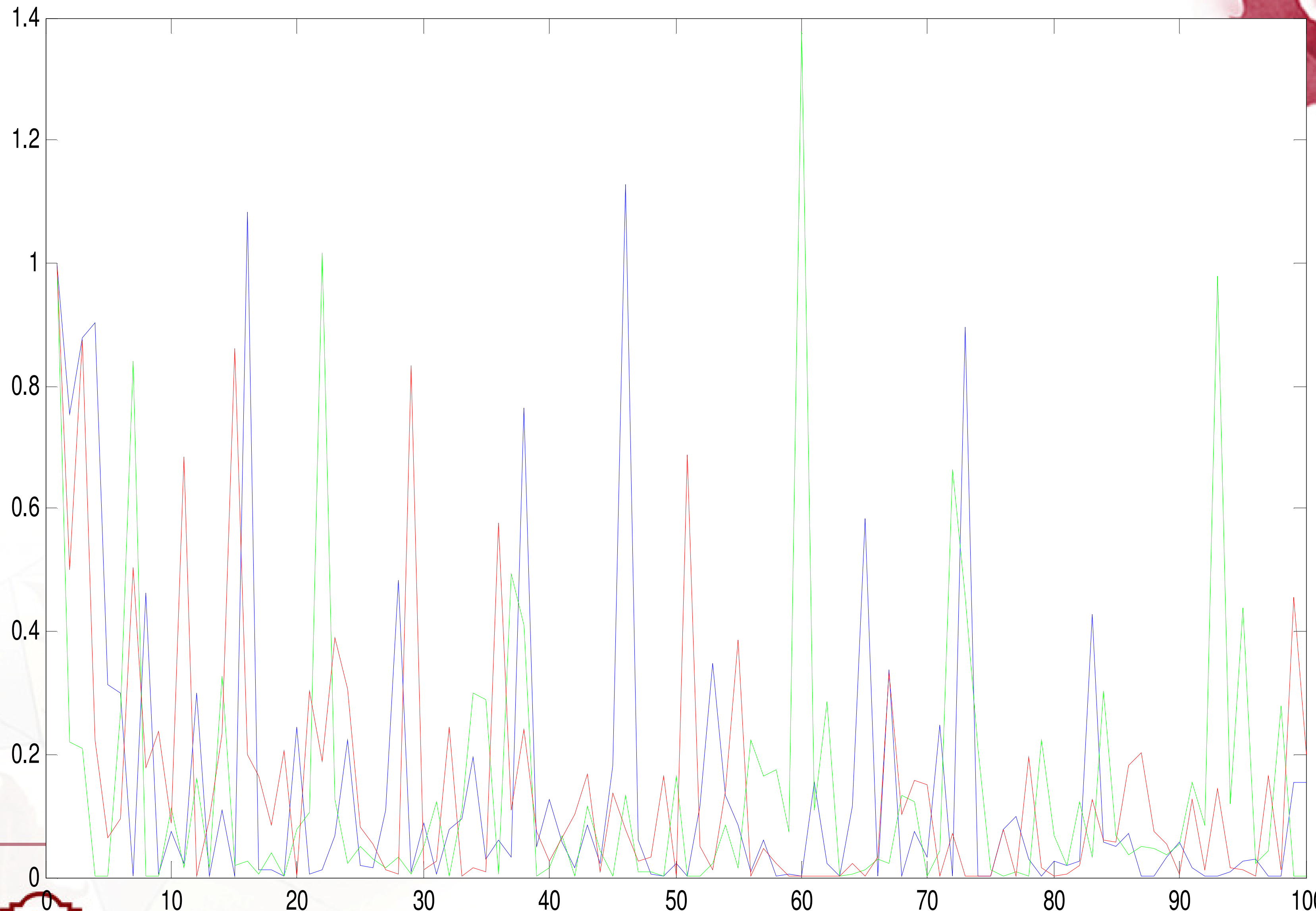

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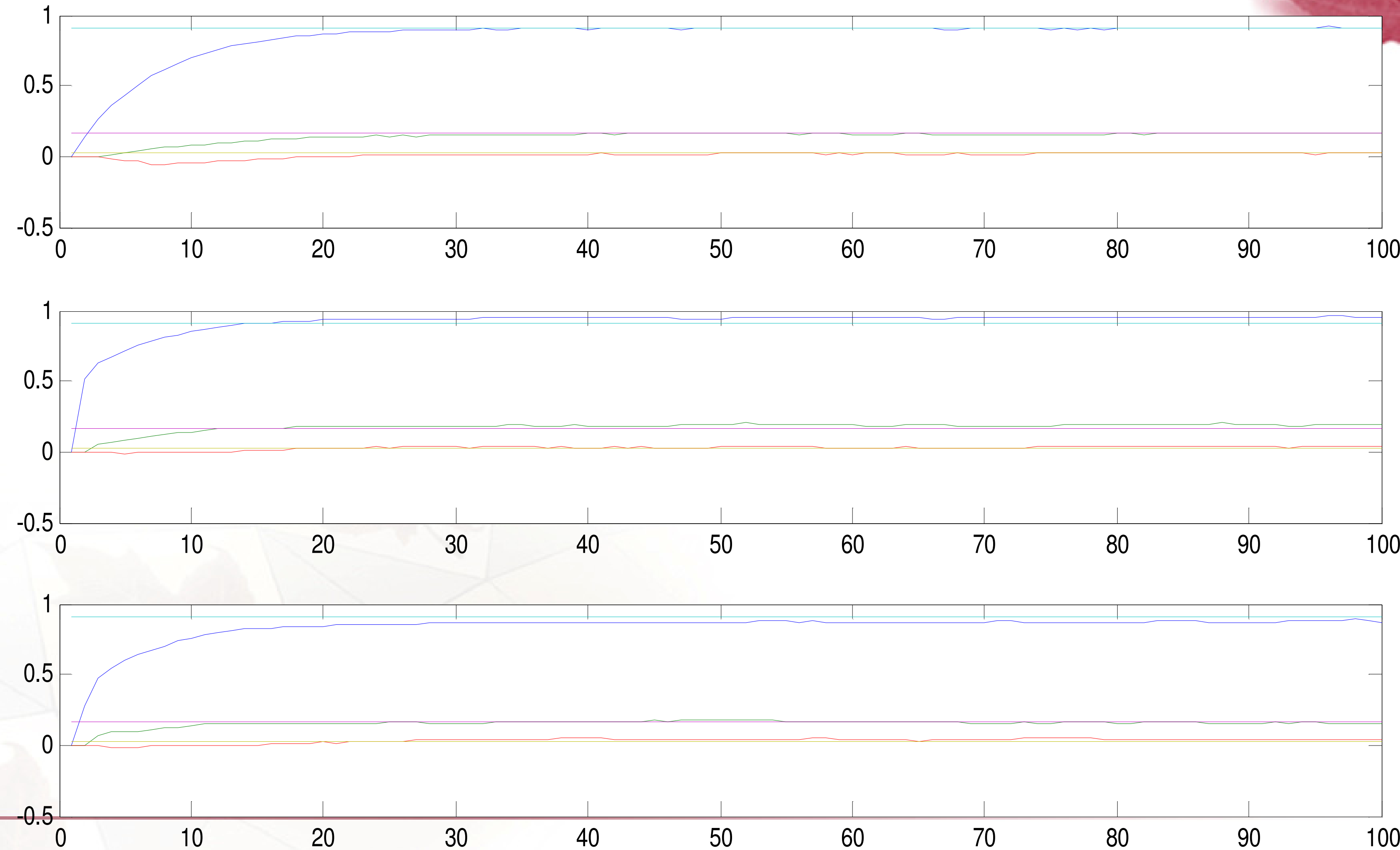
Tap weights averaged over 500 runs



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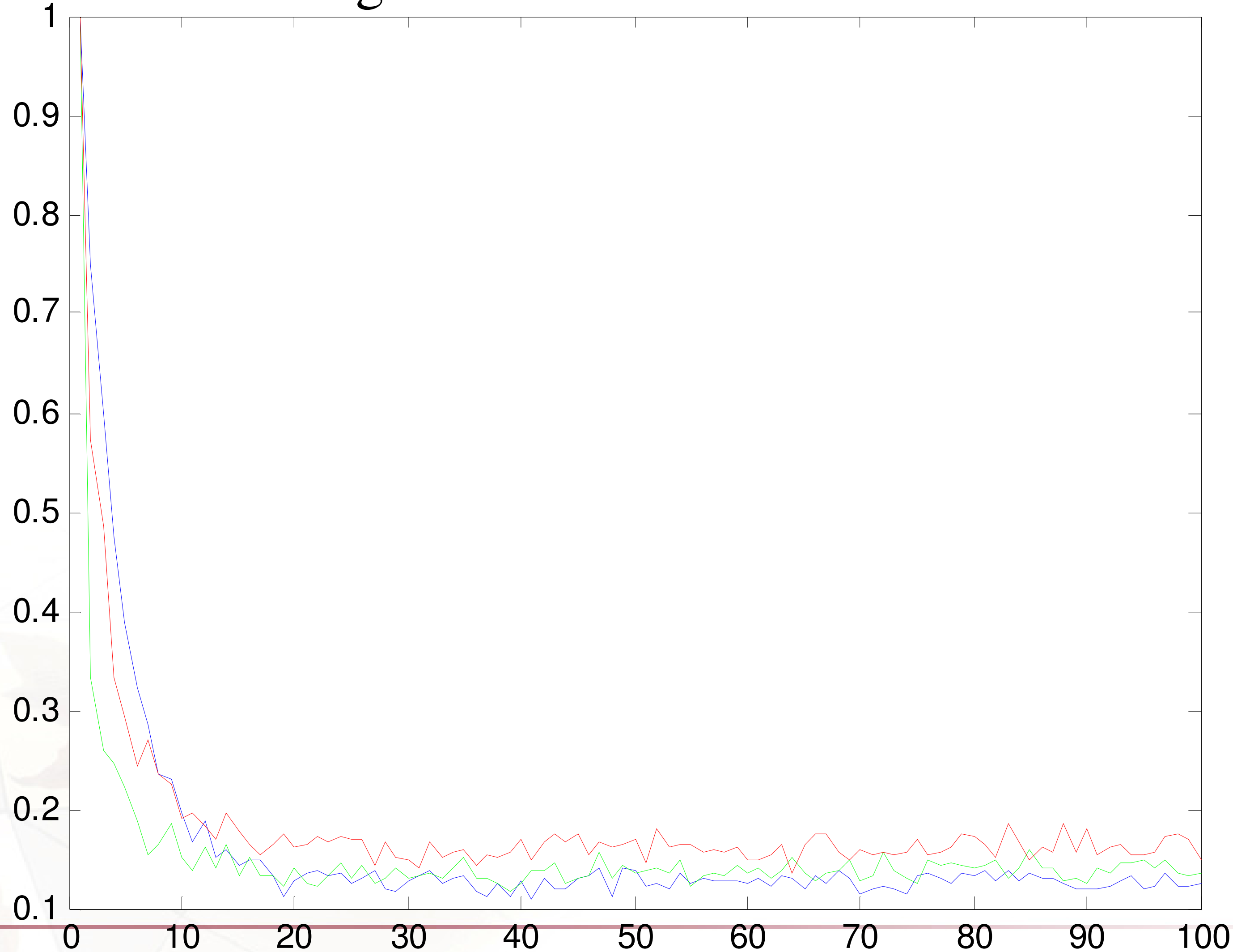
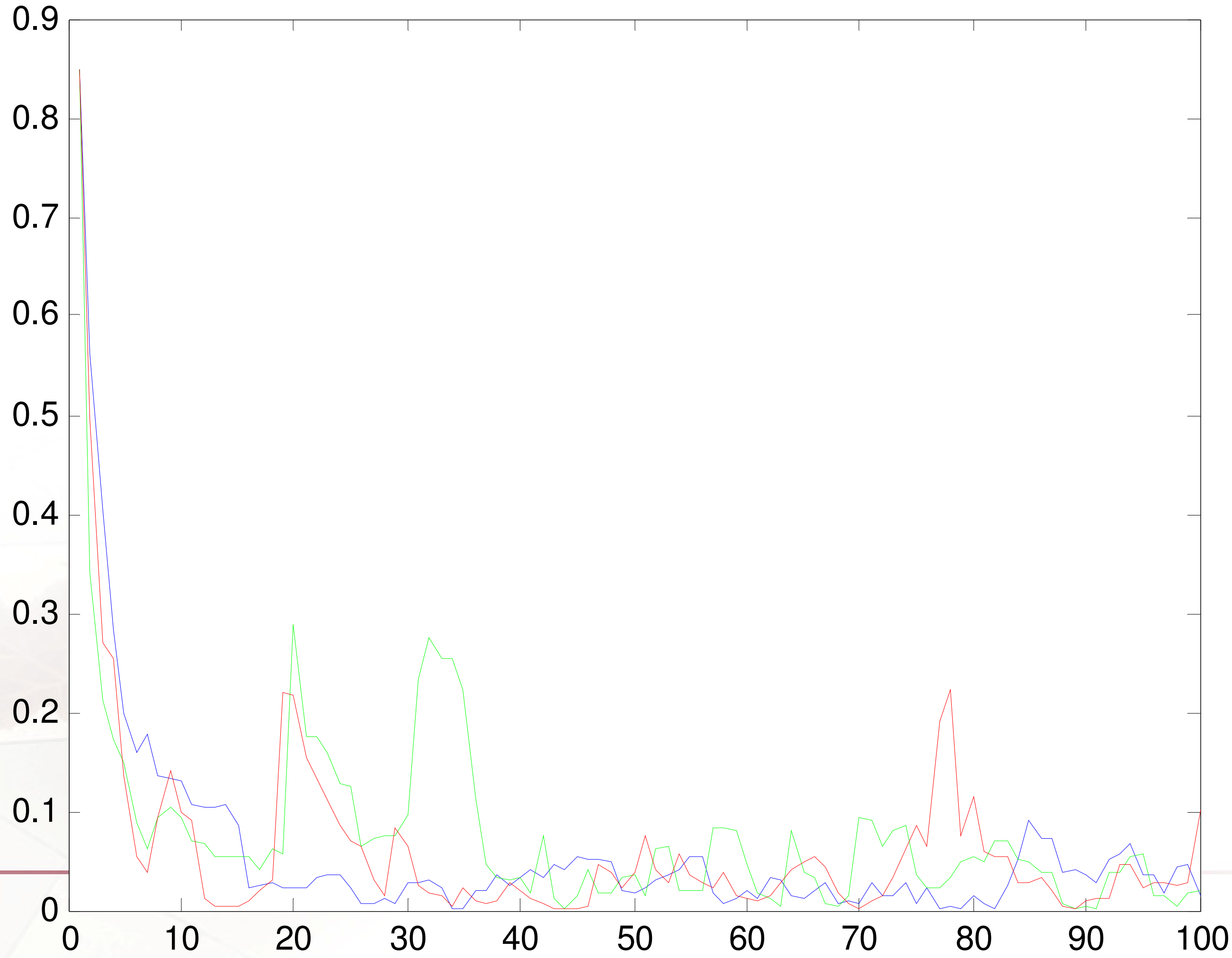
MSE averaged over 500 runs



MSDev



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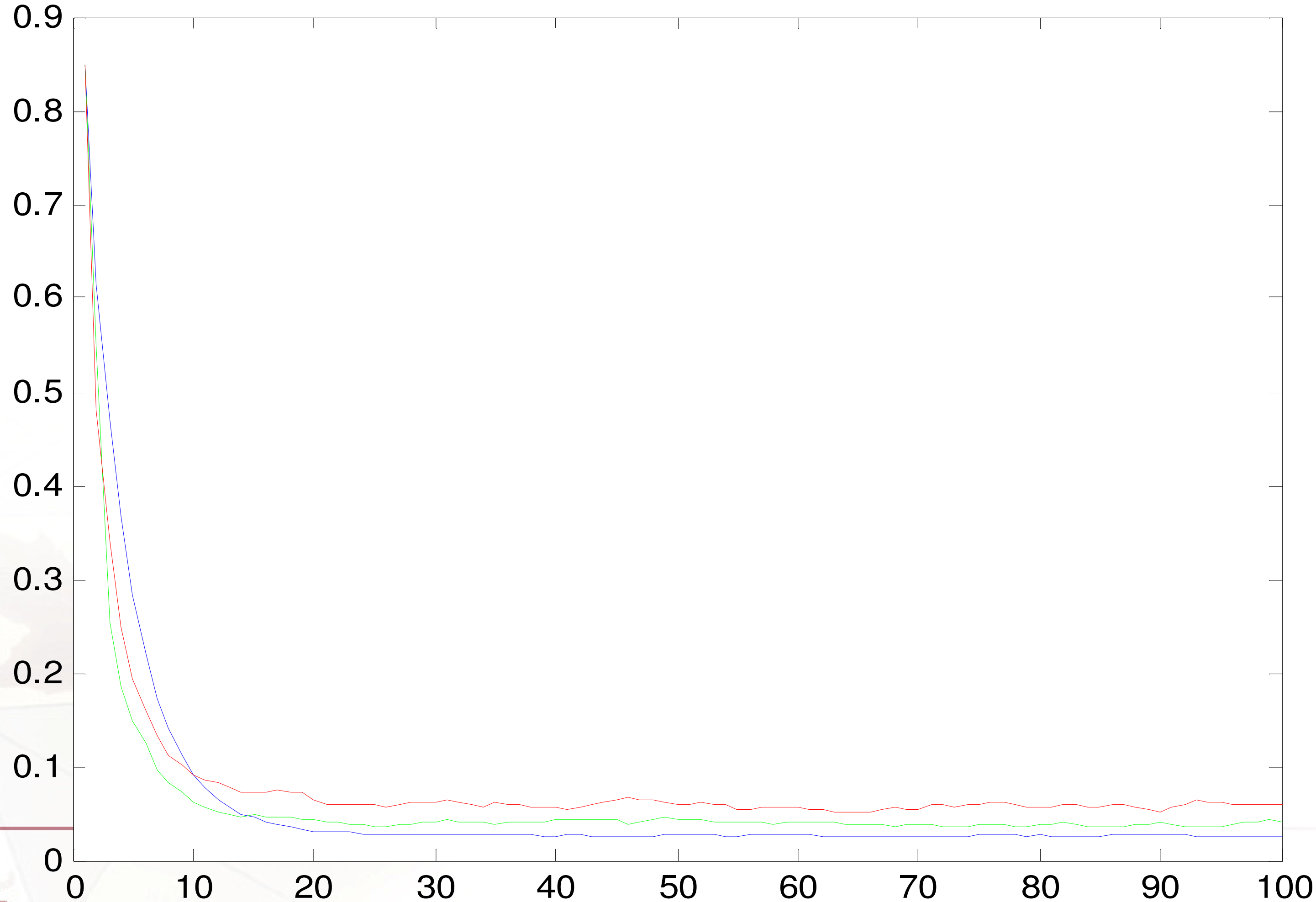
MSDev averaged over 500 runs



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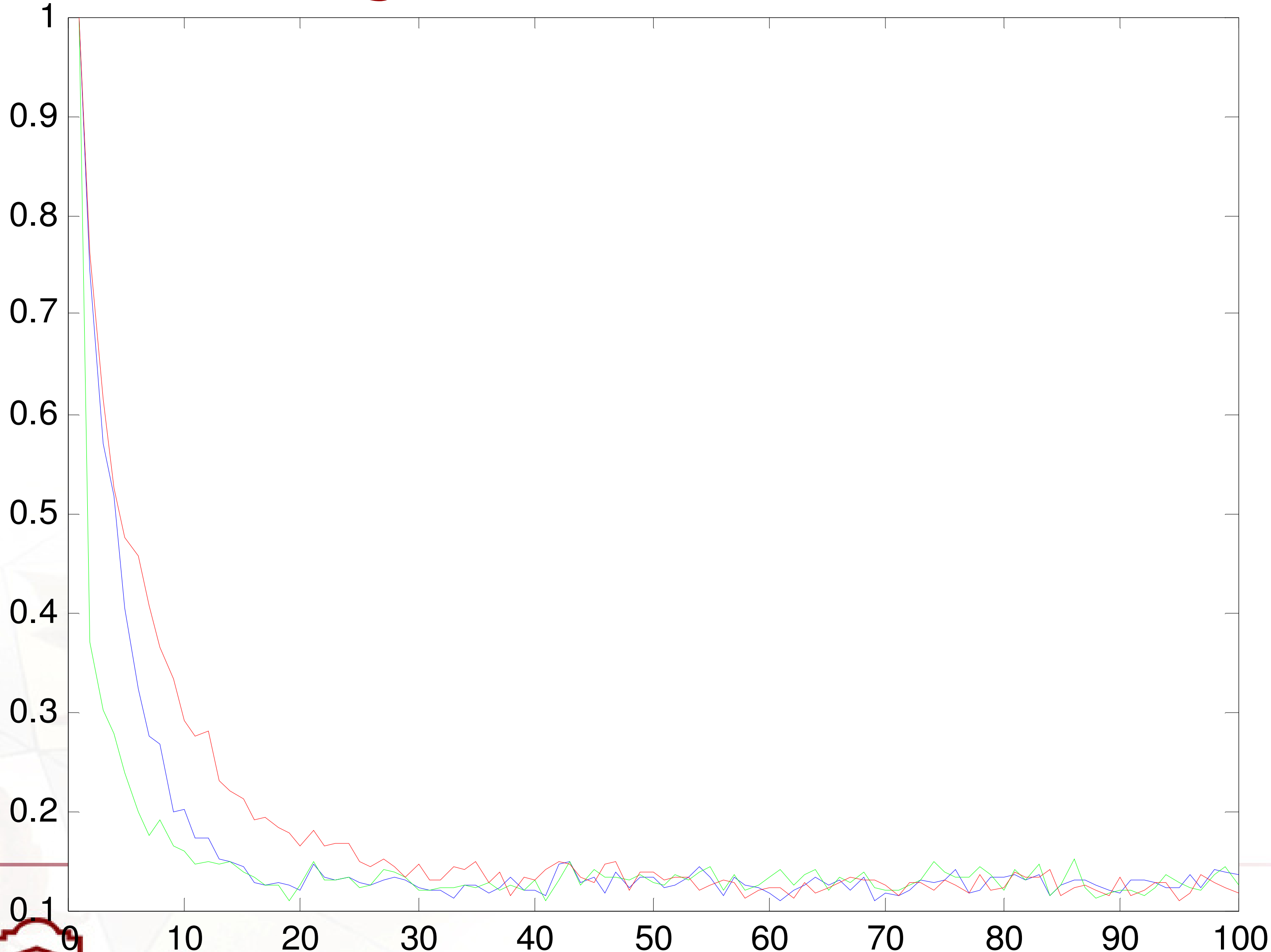
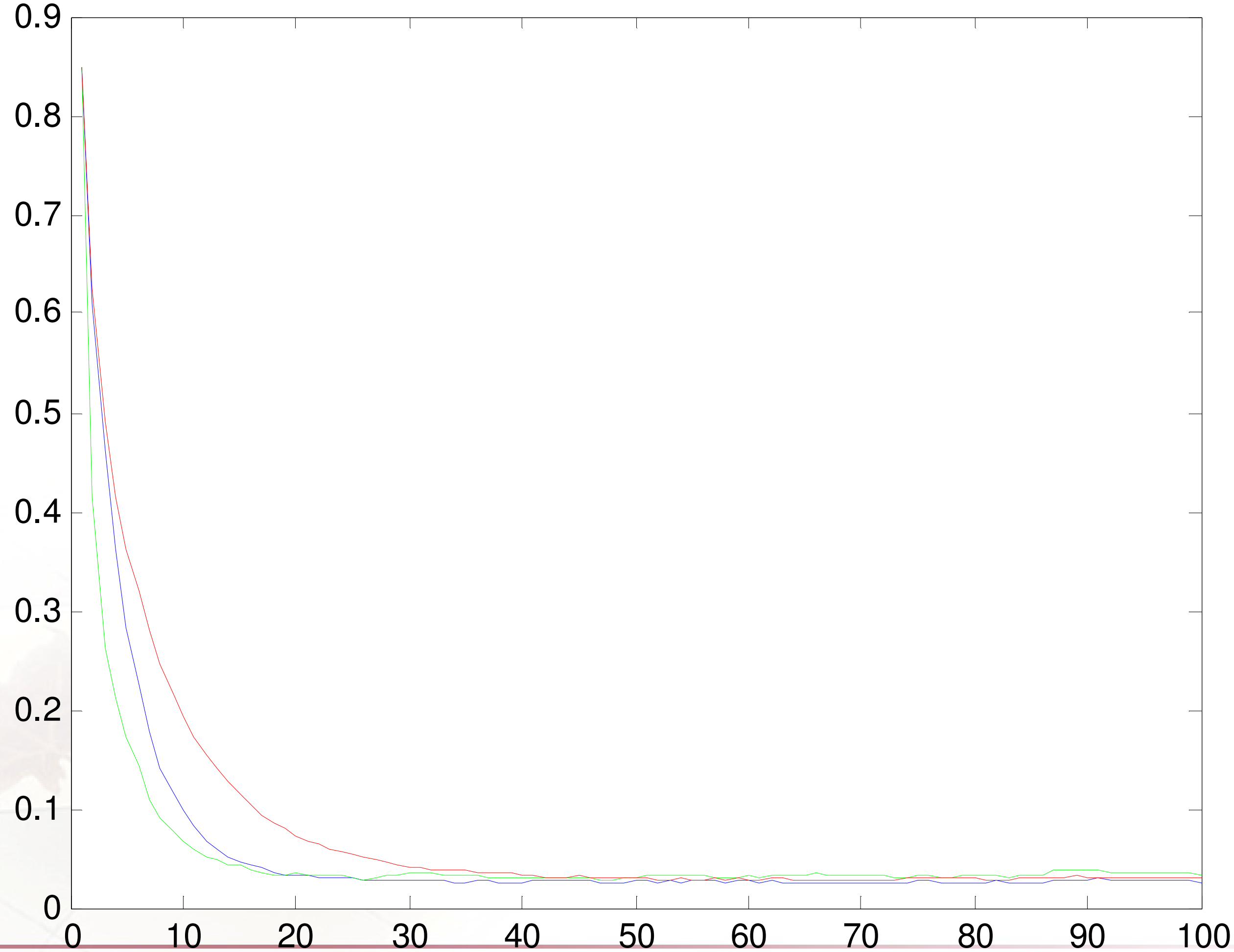
Comparison

- The misadjustment of LMS, NLMS and AP were found by simulation
  - LMS = 0.3
  - NLMS = 0.36
  - AP = 0.6
- We can adjust the values of the step sizes to try to obtain the same value of misadjustment.
- Since misadjustment is roughly proportional to the step size, we will decrease the step size in NLMS by 1.2 and by 2 in AP.

MSE averaged over 500 runs



MSDev averaged over 500 runs



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