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EXPERIMENT 6. SYSTEM IDENTIFICATION WITH ADAPTIVE PROCESSING, DESIGN AND IMPLEMENTATION OF LMS FILTER

PART 1

LABORATORY REPORT

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6.5.1. System Identification in MATLAB

Simulation Parameters

K=10000 number of samples

N=5 length of FIR filter (unknown system)

h[n]= [1 -0.8 0.6 -0.4 0.2] unknown system impulse response

σ_v = noise standard deviation of v; (square root of variance)

M= adaptive filter length

μ= step size of LMS algorithm

a)

- **Take M=5, μ =0.001, σ_v=0.**
- **Plot $e^2[n]$ versus n. Attach this plot. Determine the n value where convergence occurred. Write this value.**

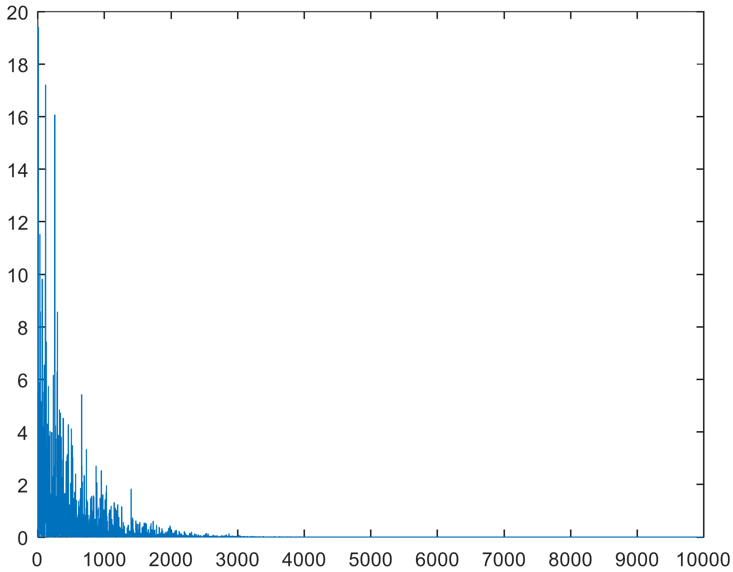

Figure 1 e^2[n] vs n

When the error is so small, we can say that the system has converged It seems the convergence value is after 1k around 1.5k

b) Change μ =0.1. Plot $e^2[n]$ versus n. Attach this plot. Determine the n value where convergence occurred. Write this value.

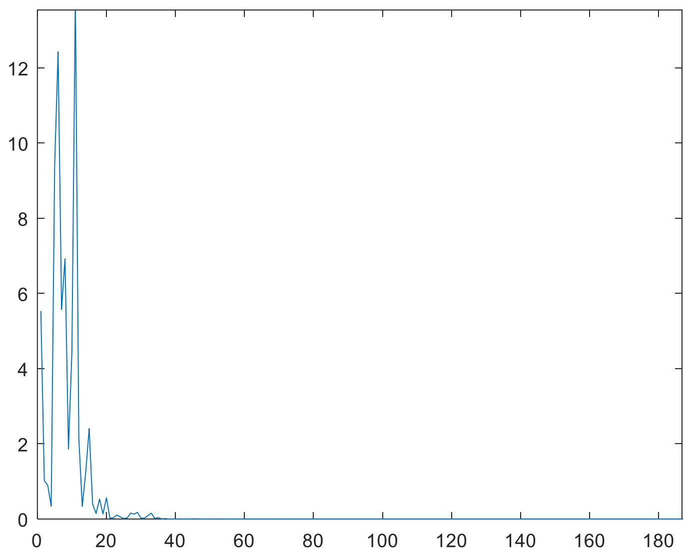

Figure 2 e^2[n] vs n when mu is 0.1

Since the step size is increased, the system has converged way faster as expected. After 20 iterations the channel characteristics are found.

c) Comment on the effect of step size on the convergence speed based on your plots and observations.

As the step size increases the convergence speed increases. However, if the step size is given too much, the system may keep oscillating and the final error might be high.

d) Write the coefficients of the adaptive filter after convergence. Comment on it.

Found coefficients:

[1 -0.800000000000000 0.600000000000000 -0.400000000000000 0.200000000000000]

It is exactly the same as the channel coefficients. Because adaptive filter has tracked it.

e) Change noise standard deviation from σ_v=0 to σ_v=0.2. Take μ =0.001. Plot $e^2[n]$ versus n. Attach this plot. Compare it with the noiseless case, part a). Comment on it.

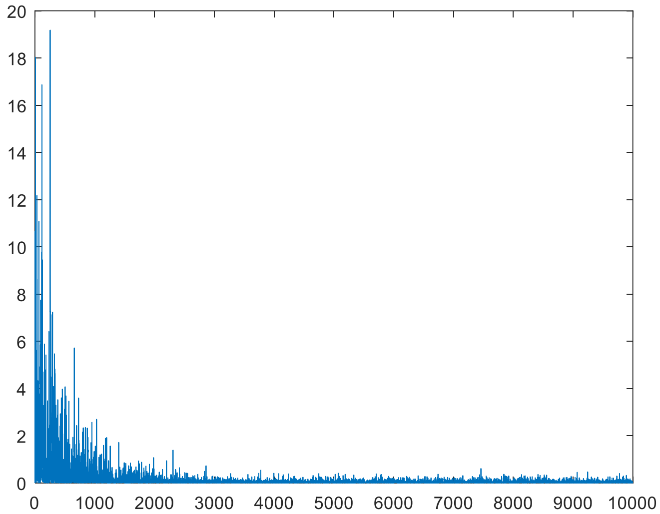

Figure 3 e^2[n] vs n when mu is 0.001 and there is noise

Due to the noise we could not find the exact coefficients. However, the found coefficient values are very close to the original ones. So the channel can still be found. Due to the noise, a little error exists even after the convergence.

Found coefficients: [1.006647897774917 -0.797058054595642 0.601709520533063 -0.399047767424931 0.198415104320716]

f) Keep the noise standard deviation at σ_v=0.2. Take μ =0.1. Plot $e^2[n]$ versus n. Attach this plot. Compare it with the noiseless case, part b). Comment on it.

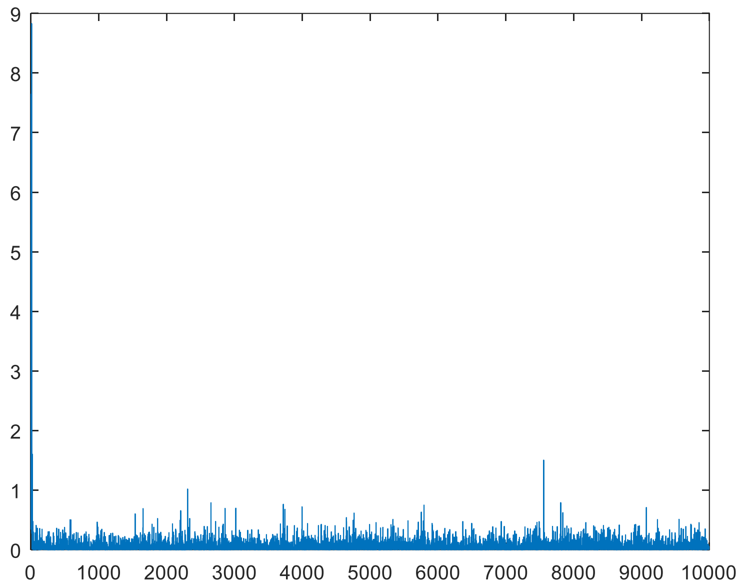

Figure 4 e^2[n] vs n when mu is 0.1 and there is noise

Since there is a noise, there is no absolute convergence. As we increased the step size, it converged faster, however the error swing is higher. There is more error after convergence in this case.

g) Write the approximate final error power after convergence for part e) and part f). Comment on the effect of step size on the misadjustment.

When the step size is 0.001 the final error power is 0.149261843564885
When the step size is 0.1 the final error power is 0.059362642173377
When the step size is 0.3 the final error power is 1.239312815277967e+05

It can be seen that the final error power is related with the step size. At first, a small increment may affect in a good way. It may both converge fast and the error might be lower since the desired point can be caught. However, after some point, the noise affect is less than the effect of step size. In other words, while the system is trying to compensate the error from the noise, it misses the desired point due to high step size. So error gets increased. There is a trade-off.

h)

- **Take M=4, μ =0.001, σ_v=0.**
- **Plot $e^2[n]$ versus n. Attach this plot. Compare it with the previous noiseless case where M=5, part a).**

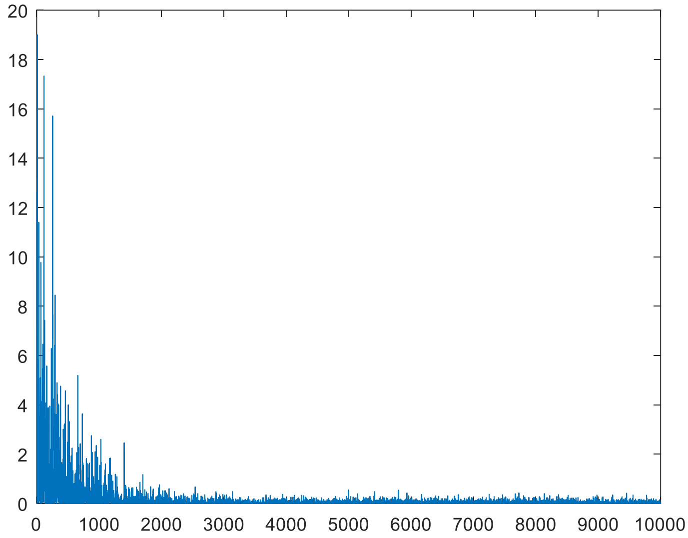

Figure 5 e^2[n] vs n when mu is 0.001 and M is 4

Since the window is decreased, we are estimating by using less samples. Therefore, there is a little bit more error in this case.

i)

- **Take M=10, μ =0.001, σ_v=0.**
- **Plot $e^2[n]$ versus n. Attach this plot. Compare it with the previous noiseless case where M=5, part a). Write the coefficients of the adaptive filter after convergence. Comment on it.**

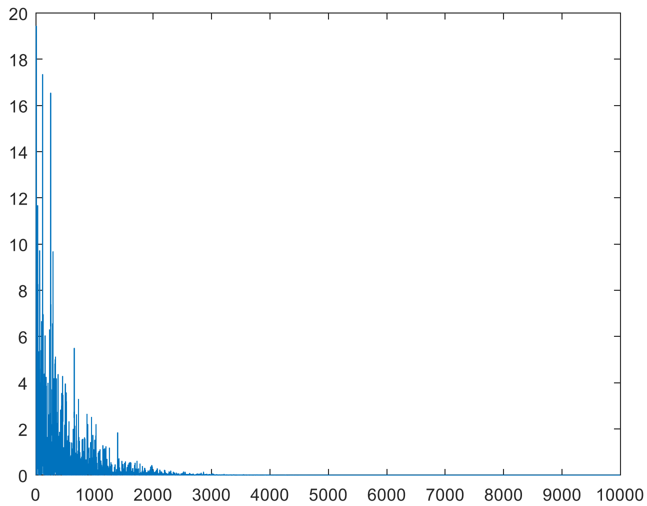

Figure 6 e^2[n] vs n when mu is 0.001 and M is 10

After convergence 0 error could be obtained. While determining the coefficients, more samples are used, as a result better estimation is done as expected. Becasue the system is time invarient. The trade off might be, if the system was time varient, while we were collecting more samples the channel might have changed. There is always a trade off. However in this case longer window is better.

In addition convergence is more or less the same.

6.5.2. Noise Cancellation in MATLAB

j)

- **Take M=5, μ =0.001, σ_v=1.**
- **Plot** $(e[n]-x[n])^2$ **versus** n**. Attach this plot. Determine the n value where convergence occurred. Write this value.**

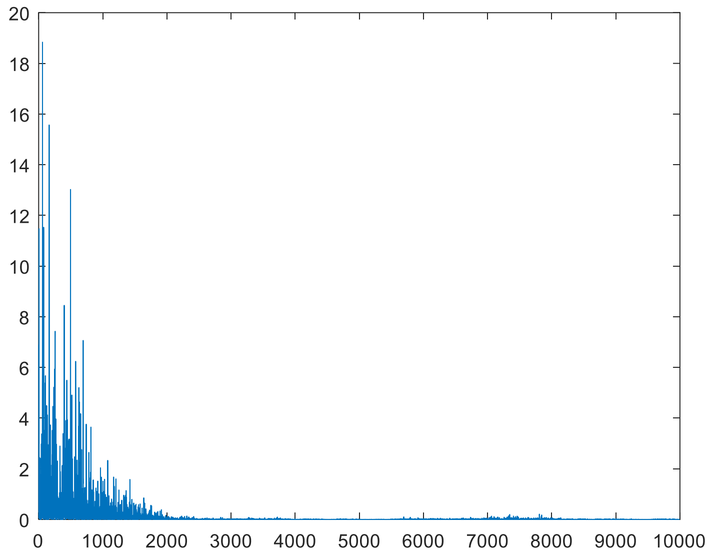

Figure 7 (e[n]-x[n])^2 vs n when mu is 0.001

Convergence occurs around 2k where the error is almost 0.

k) Change μ =0.01. Plot $(e[n]-x[n])^2$ **versus** n**. Attach this plot. Determine the n value where convergence occurred. Write this value.**

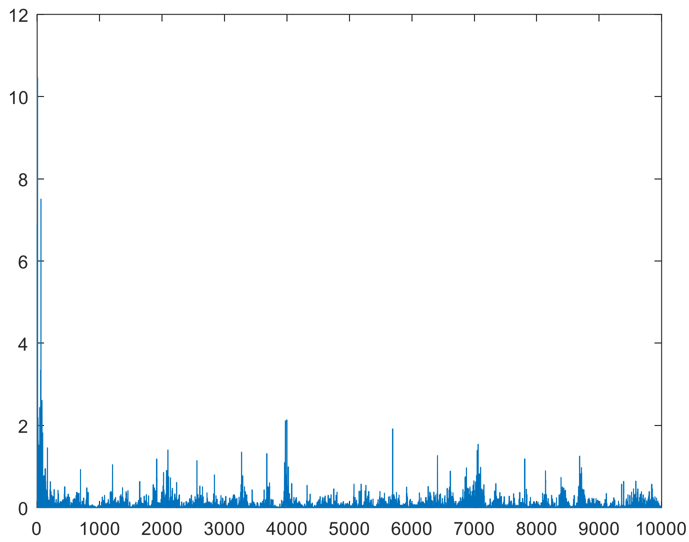

Figure 8 (e[n]-x[n])^2 vs n when mu is 0.01

The step size has increased; it has converged faster but oscillated.

l) Write the coefficients of the adaptive filter after convergence. Comment on it.

Filter coefficients:
[1.049566411231487 -0.806054550237710 0.663374972541435 -0.398335631750970 0.138823572839241]

They are not exactly the same as the channel. Because in this case, we are trying to chase the noise, not just the channel. It is like tracking a channel noise on it. Therefore, the coefficients are slightly different due to the noise tracking.

m) Change noise standard deviation from σ_v=1 to σ_v=2. Take μ =0.001. Plot $(e[n]-x[n])^2$ versus n. Attach this plot. Compare it with part j). Comment on it.

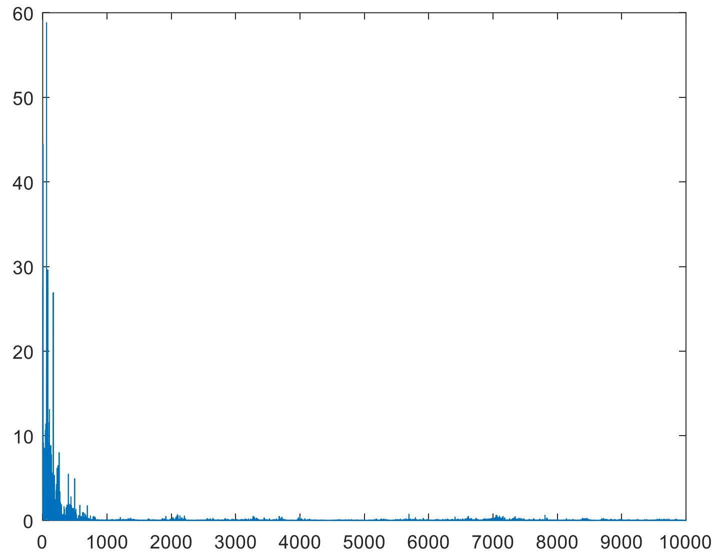

Figure 9 (e[n]-x[n])^2 vs n when noise variance is higher,2

We have decreased the step size, however the system converged faster. This shows that increasing noise variance helped system to track the noise. It can be thought as; we have more information about noise so we can track it easier.

n)

- **Take M=4, μ =0.001, σ_v=1.**
- **Plot $(e[n]-x[n])^2$ versus n. Attach this plot. Compare it with part j).**

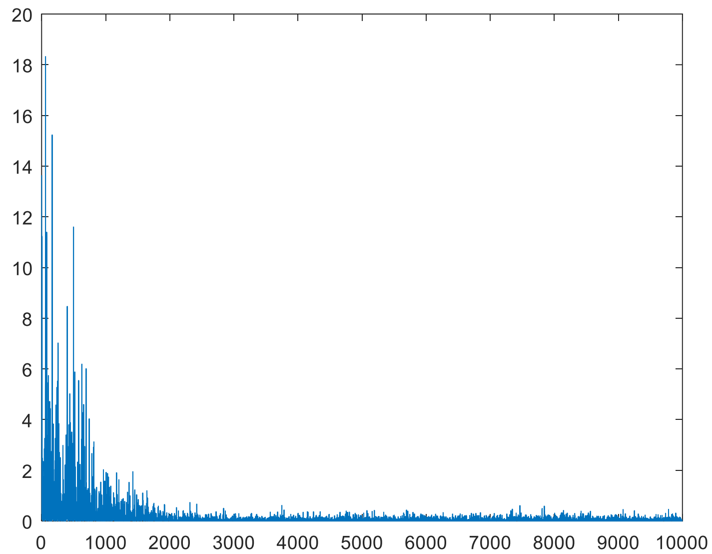

Figure 10 (e[n]-x[n])^2 vs n when M is 4

Likewise, the part 1, after convergence there is a little error exists. It does not go to 0. However, the point where the convergence occurs does not change much. In other words, convergence speed is more or less the same.

o)

- **Take M=10, μ =0.001, σ_v=1.**
- **Plot $(e[n]-x[n])^2$ versus n. Attach this plot. Compare it with part j). Write the coefficients of the adaptive filter after convergence. Comment on it.**

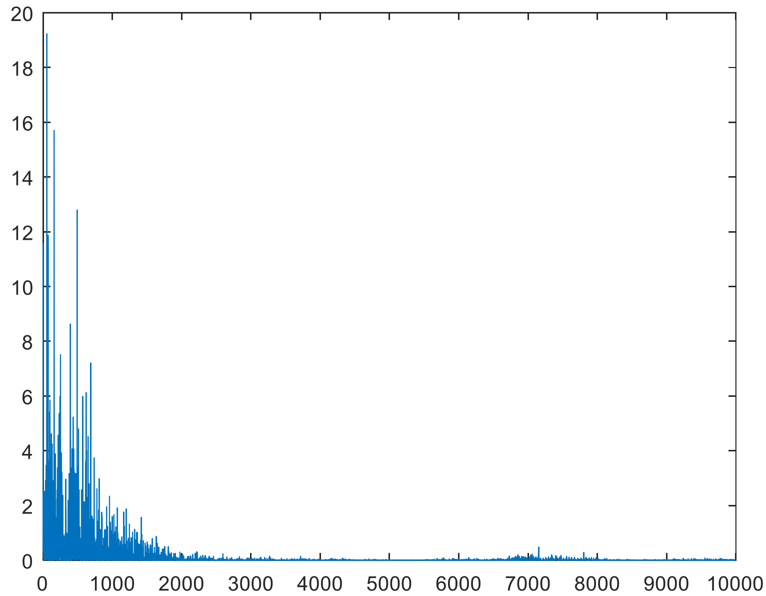

Figure 11 (e[n]-x[n])^2 vs n when M is 10

Likewise, the part 1, when the window is higher we have more information about the (channel+noise) so that the error can converge to 0. The convergence speed is more or less the same.