Separable Least-Mean Squares Beamforming

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Outline

Introduction

- Comparisons with LMS, NLMS,ATLMS and TLMS.
- Convergence Analysis ?

System Model

Implemented Algorithms I

Algorithm 1 Tensor LMS algorithm

Require: Step parameter μ, sample size K

$k \leftarrow 1$

Initialize $\mathbf{w}_h[k]$ and $\mathbf{w}_v[k]$ as $[1, 0, \ldots, 0]^{\mathsf{T}}$

for $k = 1 : K$ **do** ▷ Note we use MATLAB's notation

$\quad \mathbf{u}_h[k] \leftarrow \mathbf{X}[k]\mathbf{w}_v^*[k]$

$\quad \mathbf{u}_v[k] \leftarrow \mathbf{X}[k]^{\mathsf{T}}\mathbf{w}_h^*[k]$

$\quad e[k] \leftarrow s_d[k] - (\mathbf{w}_v[k] \otimes \mathbf{w}_h[k])^{\mathsf{H}}\mathbf{x}[k]$

$\quad \tilde{\mu}[k] \leftarrow \frac{\mu}{\|\mathbf{u}_h[k]\|_2^2 + \|\mathbf{u}_v[k]\|_2^2}$

$\quad \mathbf{w}_h[k+1] \leftarrow \mathbf{w}_h[k] + \tilde{\mu}[k]\mathbf{u}_h[k]e^*[k]$

$\quad \mathbf{w}_v[k+1] \leftarrow \mathbf{w}_v[k] + \tilde{\mu}[k]\mathbf{u}_v[k]e^*[k]$

$\quad$ Check convergence

end for

return $\mathbf{w}_v[k+1] \otimes \mathbf{w}_h[k+1]$

Figure TLMS algorithm from [1].

Implemented Algorithms II

Algorithm 2 Alternating Tensor LMS algorithm

Require: Step parameter μ, sample parameters K, K_h, K_v

$k \leftarrow 1$
$K_b \leftarrow \lfloor \frac{K}{K_h+K_v} \rfloor$
Initialize $\mathbf{w}_h[k]$ and $\mathbf{w}_v[k]$ as $[1, 0, \ldots, 0]^{\mathsf{T}}$
for $k = 1 : K_h + K_v : K_b(K_h + K_v)$ **do**
    for $k_h = k : k + K_h - 1$ **do**
        $\mathbf{u}_h[k_h] \leftarrow \mathbf{X}[k_h]\mathbf{w}_v^*[k_h]$
        $e[k_h] \leftarrow s_d[k_h] - (\mathbf{w}_v[k_h] \otimes \mathbf{w}_h[k_h])^{\mathsf{H}}\mathbf{x}[k_h]$
        $\tilde{\mu}_h[k_h] \leftarrow \frac{\mu}{\|\mathbf{u}_h[k_h]\|_2^2}$
        $\mathbf{w}_h[k_h + 1] \leftarrow \mathbf{w}_h[k_h] + \tilde{\mu}_h[k_h]\mathbf{u}_h[k_h]e^*[k_h]$
    end for
    for $k_v = k + K_h : k + K_h + K_v - 1$ **do**
        $\mathbf{u}_v[k_v] \leftarrow \mathbf{X}[k_v]^{\mathsf{T}}\mathbf{w}_h[k_v]^*$
        $e[k_v] \leftarrow s_d[k_v] - (\mathbf{w}_v[k_v] \otimes \mathbf{w}_h[k_h + 1])^{\mathsf{H}}\mathbf{x}[k_v]$
        $\tilde{\mu}_v[k_v] \leftarrow \frac{\mu}{\|\mathbf{u}_v[k_v]\|_2^2}$
        $\mathbf{w}_v[k_v + 1] \leftarrow \mathbf{w}_v[k_v] + \tilde{\mu}_v[k_v]\mathbf{u}_v[k_v]e^*[k_v]$
    end for
    Check convergence
end for
return $\mathbf{w}_v[k_v + 1] \otimes \mathbf{w}_h[k_h + 1]$

Figure ATLMS algorithm from [1].

Numerical Results I

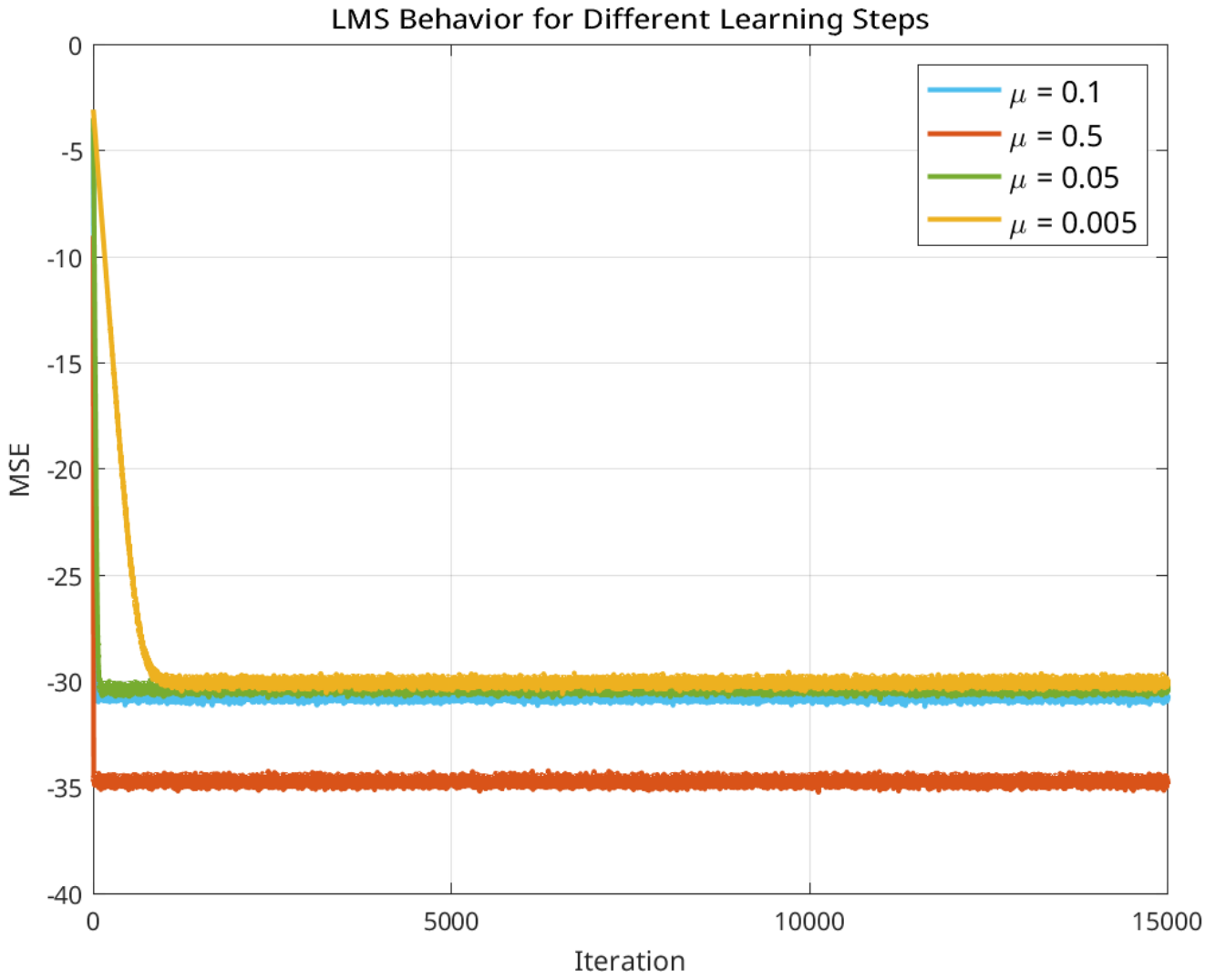

Figure Monter Carlo Experiment with 2500 runs for LMS algorithm.

Numerical Results II

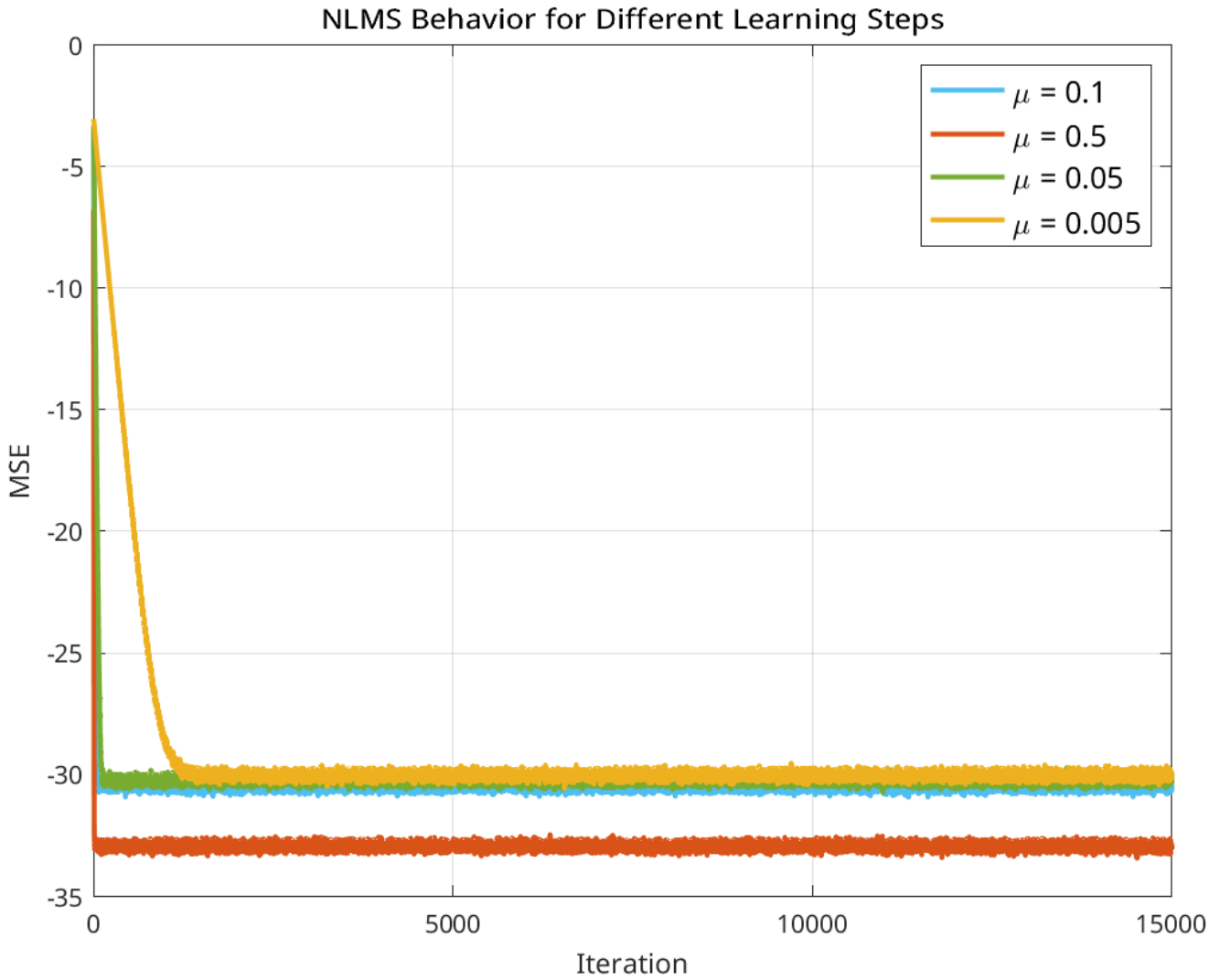

Figure Monter Carlo Experiment with 2500 runs for LMS algorithm.

Numerical Results III

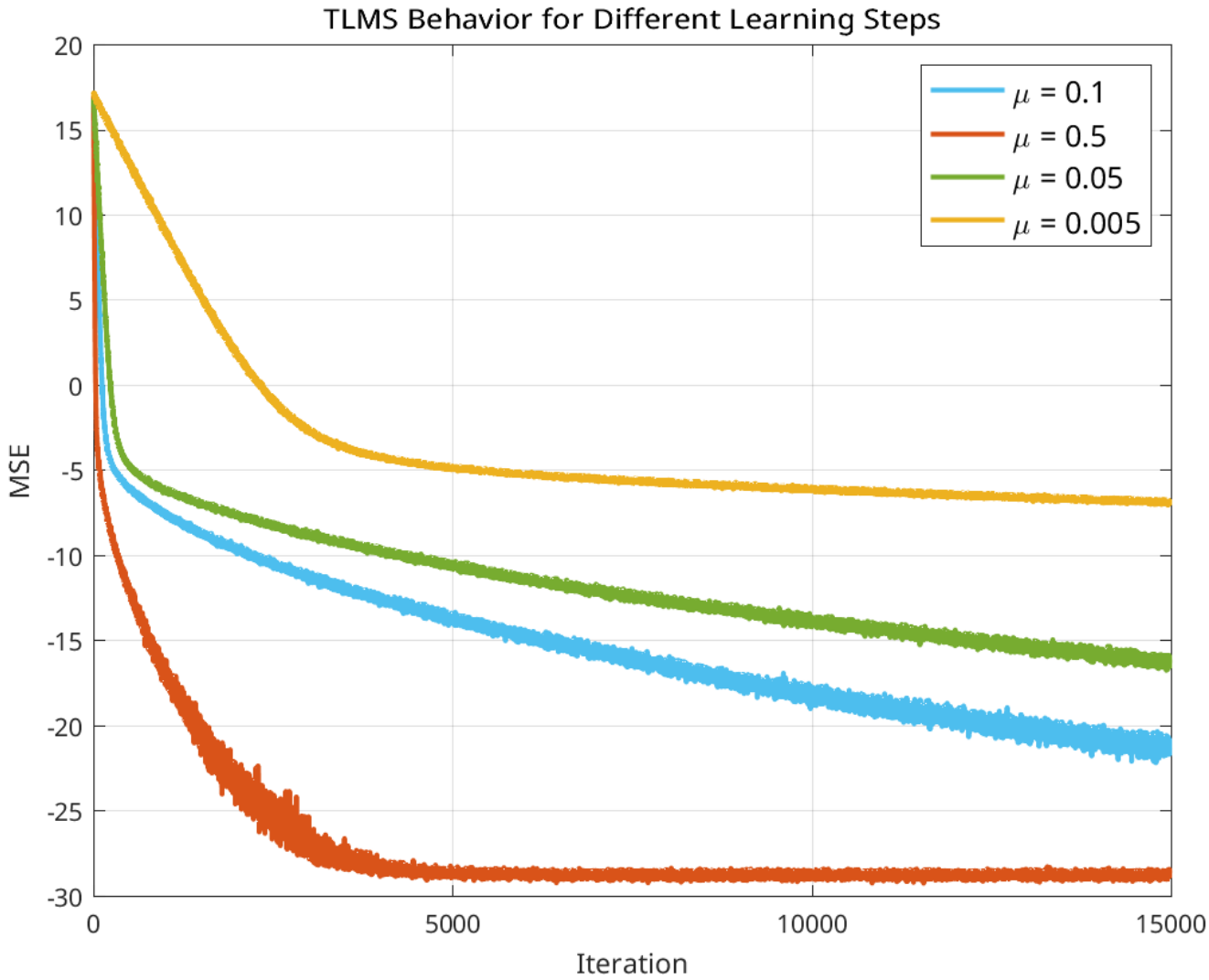

Figure Monter Carlo Experiment with 2500 runs for LMS algorithm.

Numerical Results IV

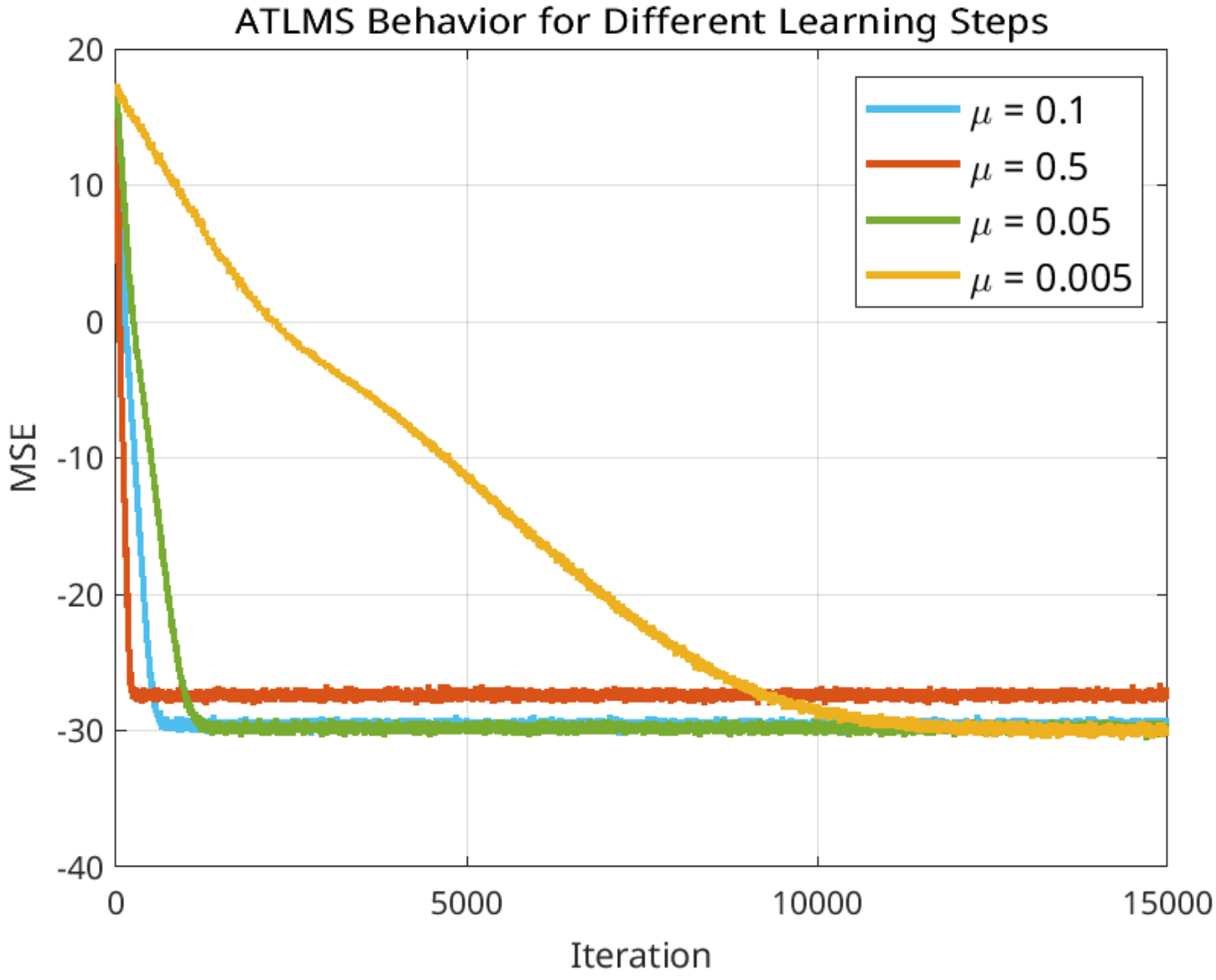

Figure Monter Carlo Experiment with 2500 runs for LMS algorithm.

Numerical Results V

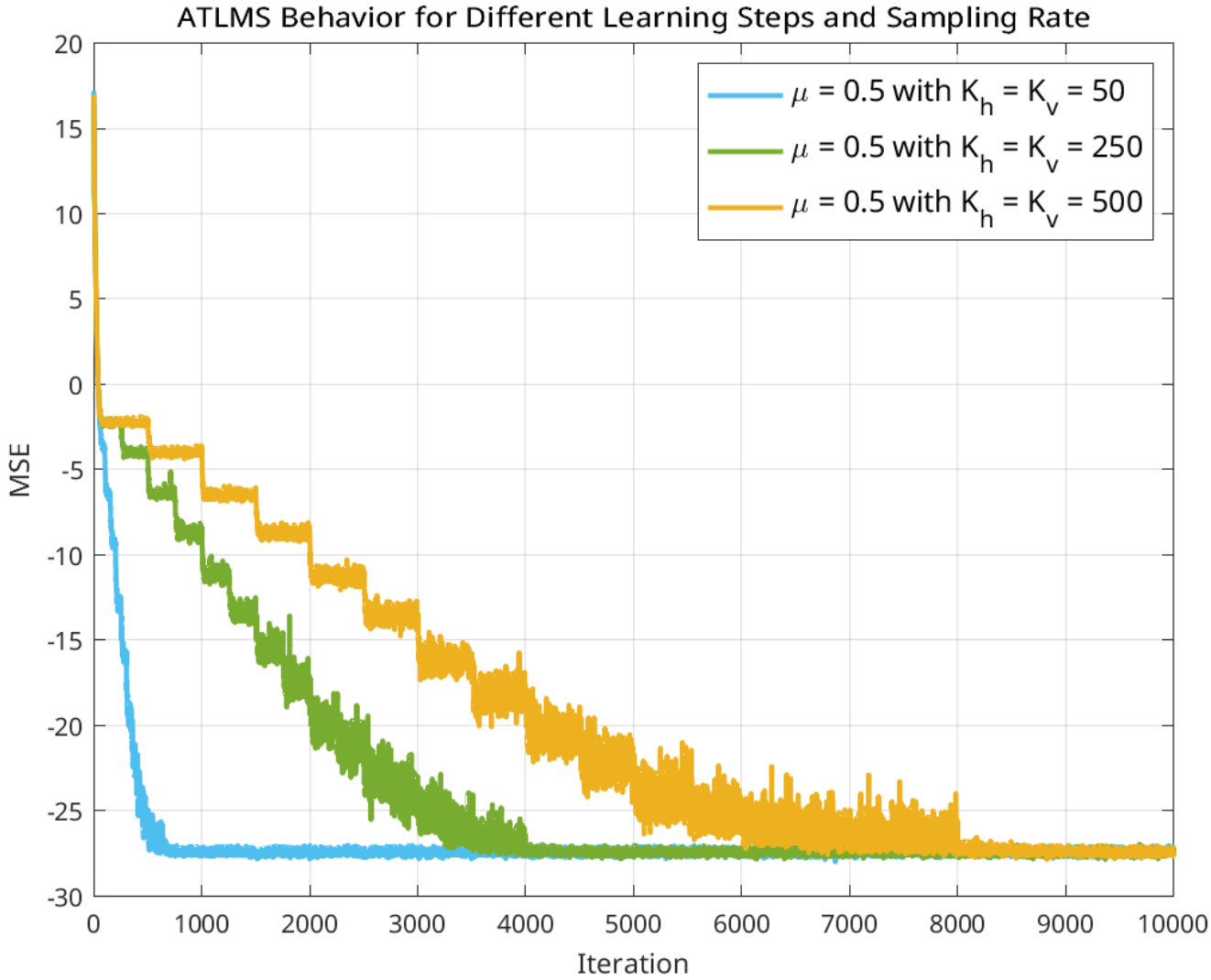

Figure Monter Carlo Experiment with 2500 runs for the ATLMS with different sampling intervals.

Numerical Results VI

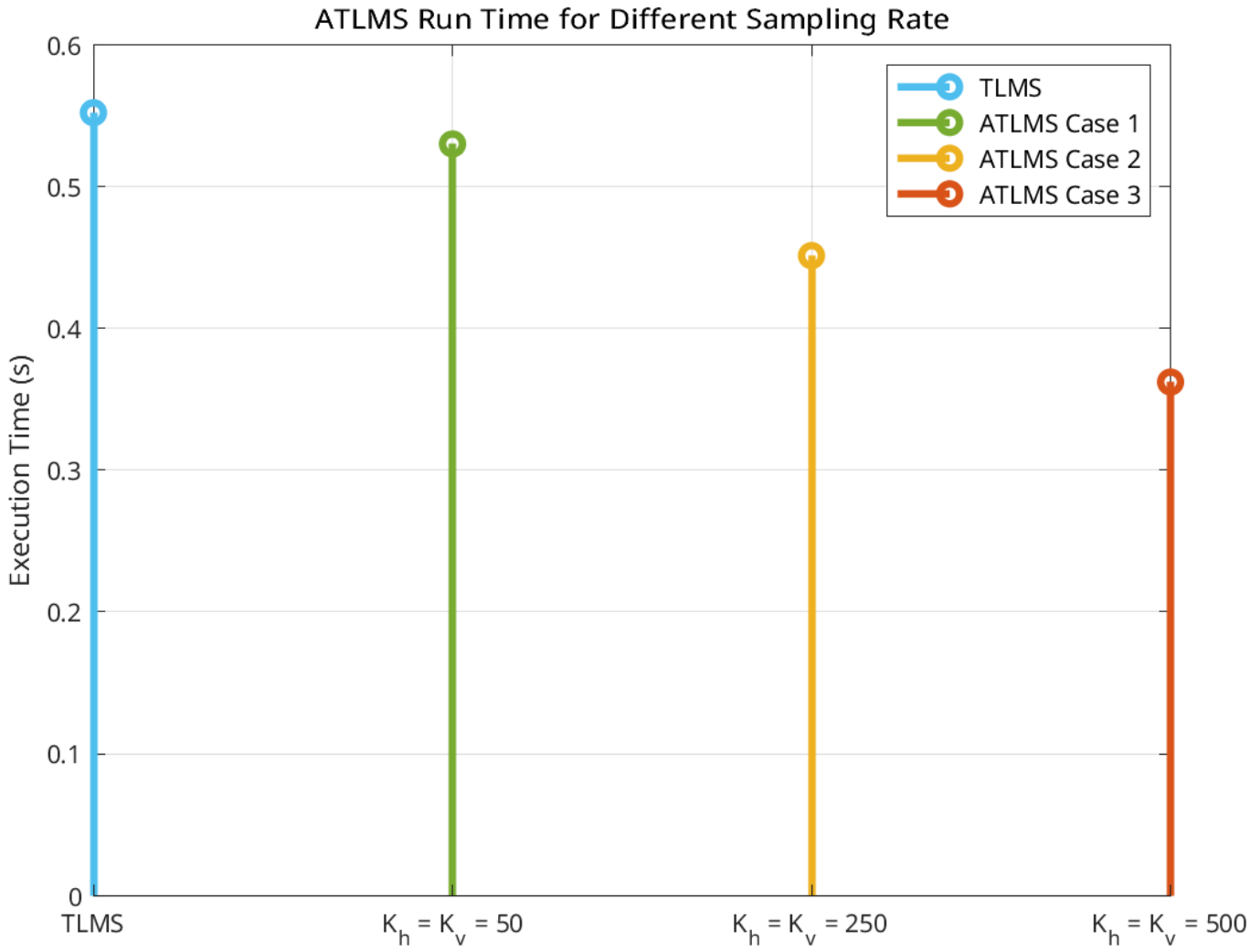

Figure Run time process for ATLMS with different sampling intervals.

References

[1] L. N. Ribeiro, B. Sokal, A. L. de Almeida, and J. C. M. Mota, "Separable least-mean squares beamforming,"

Thank you for your presence!