Variable Step Size Least Mean *p*-Power Algorithm Based on Improved Softsign Function

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INTRODUCTION

The conventional adaptive filtering algorithm in signal processing with fixed step size will lead to its stability and convergence can not be combined at the moment. To deal with this problem, the least mean *p*-power (LMP) algorithm is improved, and a variable step size least mean p-power algorithm based on an improved softsign function is proposed. The algorithm uses the improved softsign function to construct the variable step size function, while the moving weighted average method is applied to update the step size and keep the efficiency of the algorithm stable. Simulation experiments indicate that the improved variable step size LMP algorithm further reduces the steady-state error of the algorithm while maintaining the original convergence speed, thus better balancing the stability and convergence of the algorithm under the interference of ocean pulse noise compared with the existing fixed step size and variable step size algorithms.

METHODS

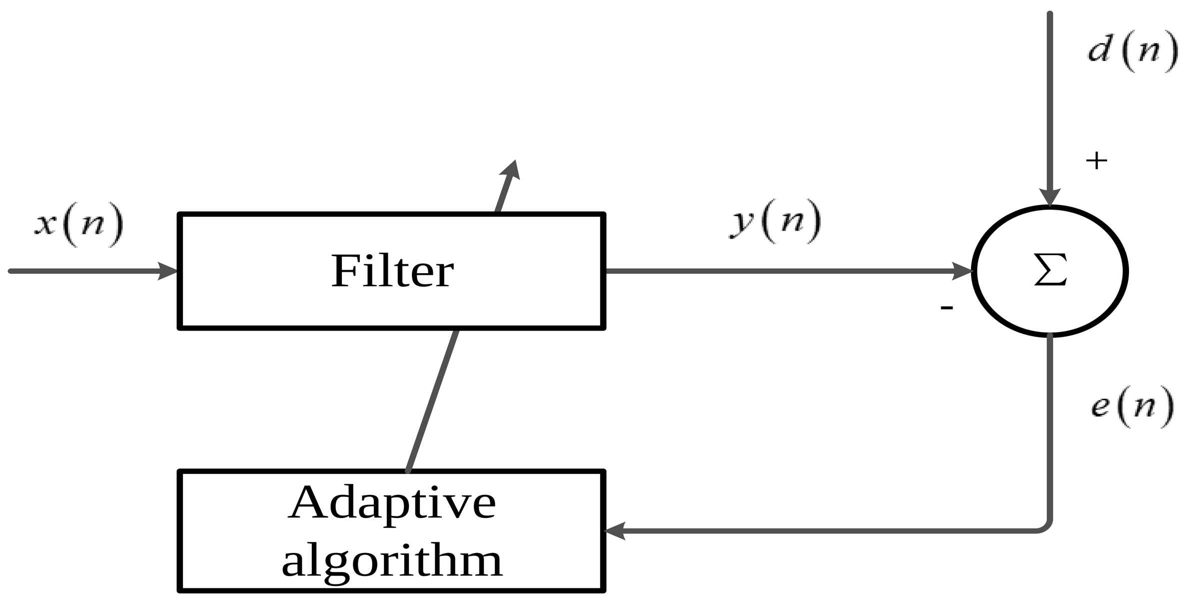


Fig. 1. Basic structure diagram of adaptive filter

The softsign function has similar properties to the tanh and sigmoid functions and can satisfy the step size adjustment principle by improving its formula. At the moment, the softsign function does not contain an exponential term compared with these two functions, which makes the calculation easier. The improved softsign function is as follows

$$f(n) = a\left(1 - \frac{m}{m + b\left|e(n)\right|}\right)$$

At the same time, the moving weighted average method is employed to automatically update the variable step size function of the algorithm, which has the following functional form

$$\mu(n+1) = \beta_{LMP}\mu(n) + (1-\beta_{LMP})\,a\left(1 - \frac{m}{m + b\left|e(n)\right|}\right)$$

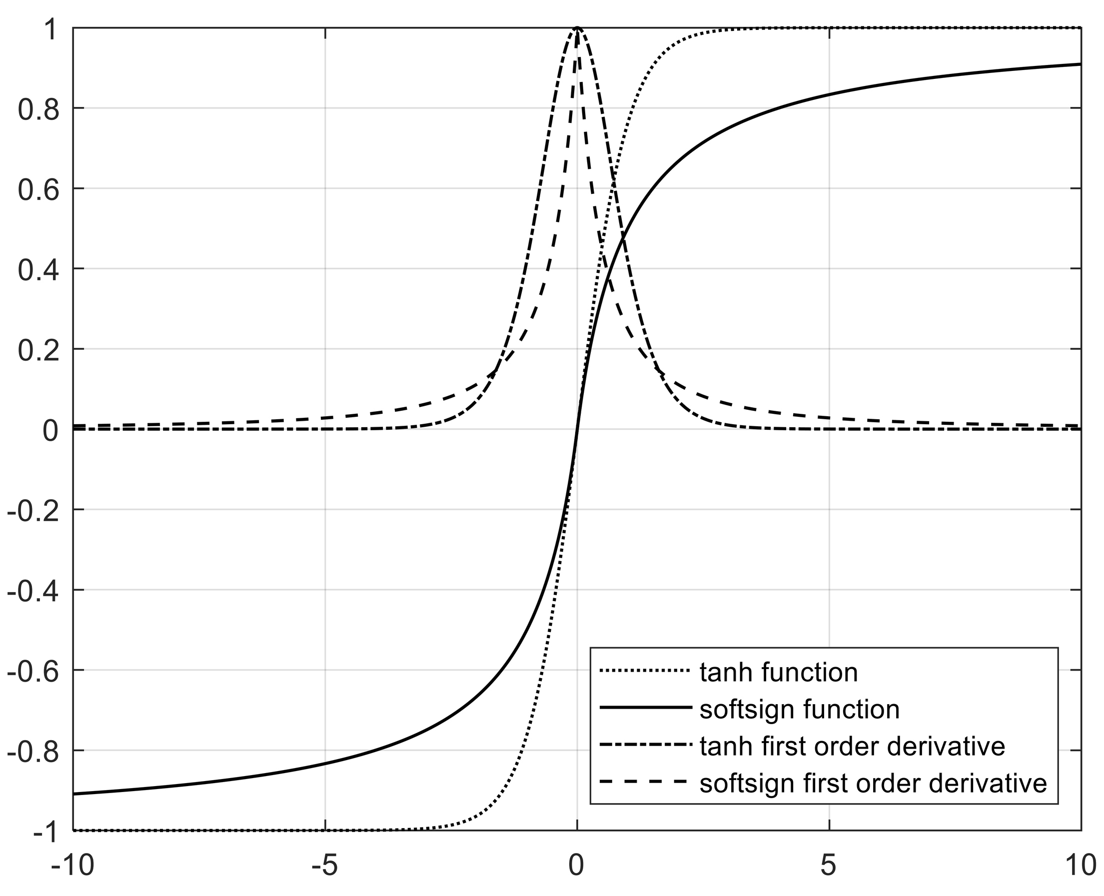
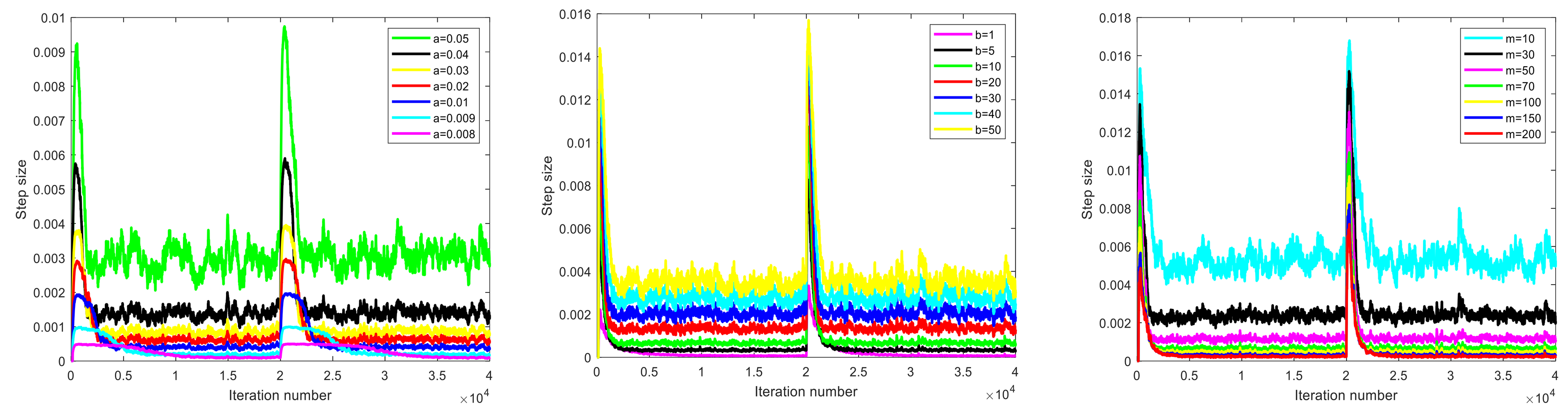


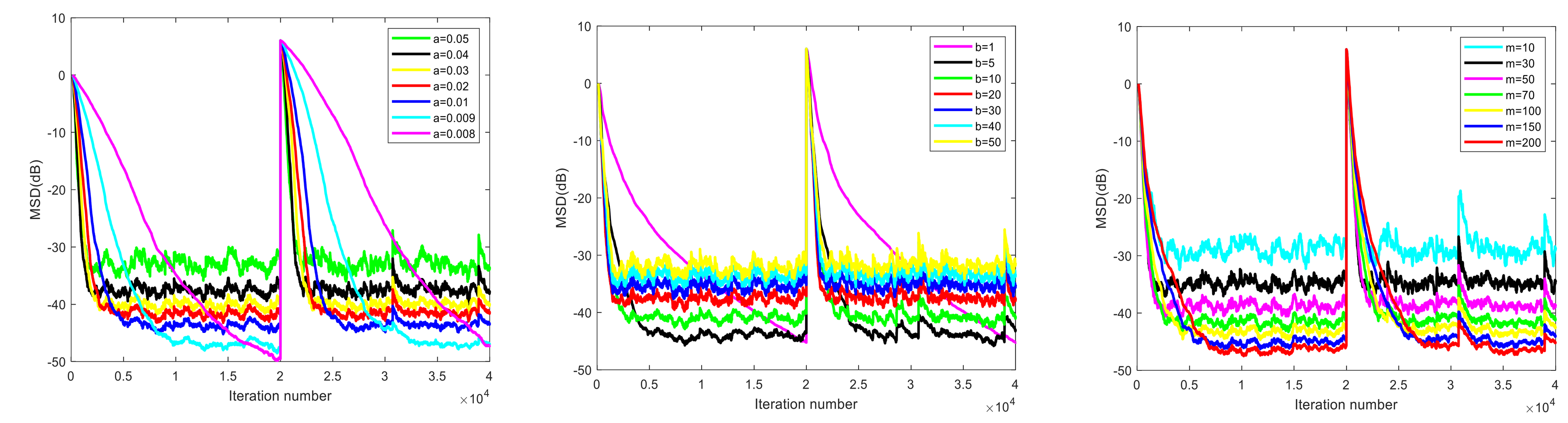
Fig. 2 Tanh function and Softsign function

PARAMETER SELECTION



(a) (b) (c)

Fig. 3. Step-size curves under different values of a, b, m



(a) (b) (c)

Fig. 4. Performance curve under different values of a, b, m

Different values of a, b, and m will seriously affect the performance of the proposed IVS-LMP algorithm, so the suitable parameter values are crucial to the overall performance of the algorithm. Under the ocean pulse noise, the simulation obtains the step size and Mean Square Deviation (MSD) graphs, from which the optimal values of the selected parameters are observed and analyzed.

SIMULATIONS

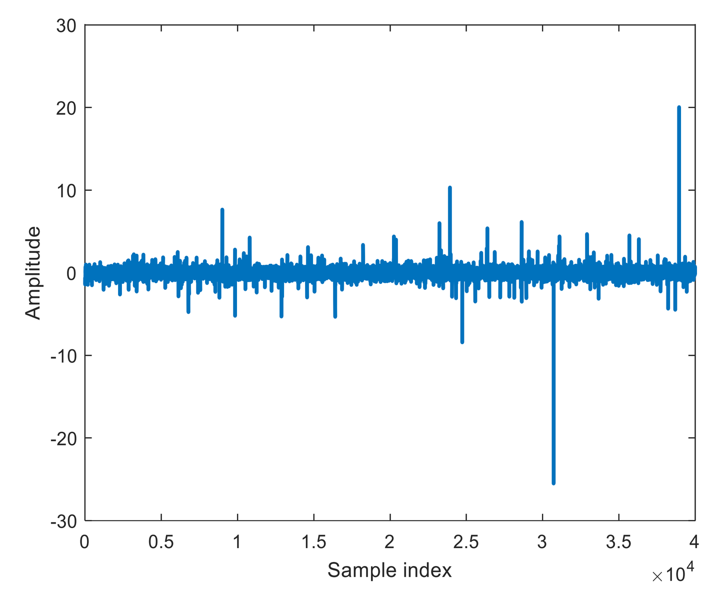


Fig. 5. Modeling signal for ocean impulse noise

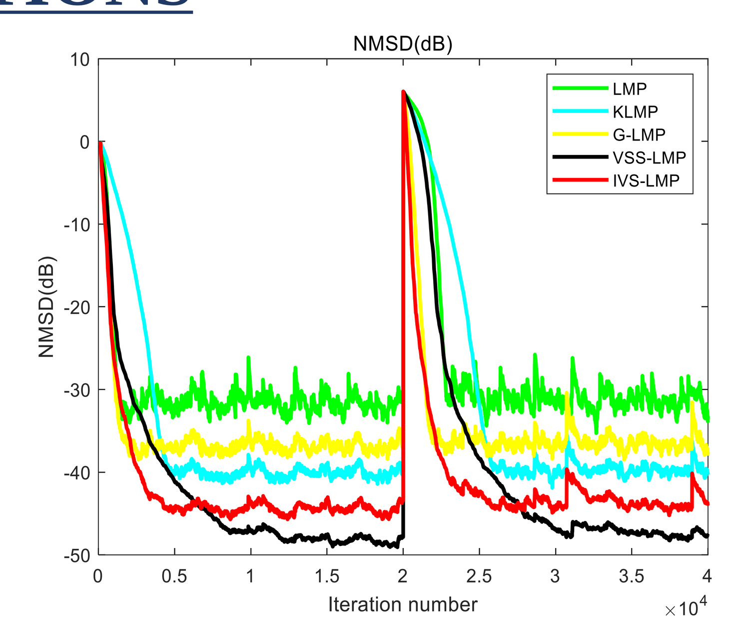


Fig. 6. Comparison of performance curves of different algorithms

The proposed IVS-LMP algorithm is close to the convergence speed compared to the fixed step size LMP and G-LMP algorithms, but the steady-state error is further reduced. And the convergence speed is further accelerated compared to KLMP and VSS-LMP algorithms. Therefore, the proposed IVS-LMP algorithm can well balance the fast convergence speed and low steady-state error.

CONCLUSION

The existing LMP algorithm in signal processing is improved to achieve a fast convergence speed while taking into account the low steady-state error of the system. This paper constructs a variable step size function by establishing a nonlinear relationship between the step factor and the error signal through a modified softsign function. A moving weighted average method is also used to automatically update the step size. The experimental simulations show that the proposed algorithm has faster convergence speed and lower steady-state error than the existing fixed step size and variable step size algorithms under the ocean pulse noise interference, thus better balancing the convergence and stability of the algorithm.