ABSTRACT

In combinations of AFs, the component filters usually run independently to be later on combined, leading to a stagnation before reaching the lower error. Conditional transfers of coefficients between the components have been introduced to address this issue. This work proposes a more natural way of accelerating convergence, using cyclic feedbacks of the overall weights to the components instead of unidirectional conditional transfers. It is shown that the cycle length can turn the resulting recursion into an independent combination, a variable step size AF or a hybrid algorithm. Comments on the universality of the approach are presented along with a technique to design the cycle length. Comparisons in different system identification scenarios show the superior performance of the new method.

INTRODUCTION

• Combination of adaptive filters
  • Used when accurate design of a single filter is difficult (e.g., improve the transient/steady-state trade off)
  • Definition: set of independent AFs combined by a mixing parameter
  • Problem: convergence stagnation
  • Possible solutions: Different structures (incremental-cooperative) and conditional transfers of coefficients.

Convex combination of LMS filters (CLMS)

Transfer of coefficients

The cycle length effect

The cycle length can turn the resulting recursion into an independent combination, a variable step size AF or a hybrid algorithm.

CYCLIC COEFFICIENTS FEEDBACK

A BRIEF ON ANALYSIS

• The cycle length effect

VSS

CLMS

L

∞

\begin{align*}
\lambda(i) & = \frac{1}{1 + e^{-\lambda(i-1)}} \\
\alpha(i) & = \alpha(i-1) + \mu_\alpha(e(i)y_1(i) - y_2(i))\lambda(i)[1 - \lambda(i)]
\end{align*}

\(\lambda(i) \geq 0.98\)

More natural: provides all filters with the global weights

Feedback is neither directional nor limited to any two filters

Unidirectional transfer, while in real scenarios the faster AF may change (non-stationary or low SNR environments)

THE STAGNATION PROBLEM

• Adaptive filters

\[w_{n+1} = w_{n+1} + D_n\]

• Combination of adaptive filters

\[w_{n+1} = \sum_{i=1}^{N} \lambda_i(n)w_{n+1}

\]

\[\lambda_i(n) \text{ chosen to minimize } \text{E}[E(e(n)^2)] \text{ subject to } \sum_{i=1}^{N} \lambda_i(n) = 1

\]

\[o(i) = d(i) - w_{n+1} \text{ overall error;}

\[w_i \times M \text{ regressor vector;}

\[e(i) = w_o + e(i) \text{ desired signal;}

\[d(i) = e(i) \text{ input;}

\[L \times n \text{ vector that models the unknown plant.}

\]

\[e(i) = d(i) - w_{n+1} \rightarrow \text{component filters errors}

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More natural: provides all filters with the global weights

Feedback is neither directional nor limited to any two filters

Depends uniquely on counters and allow efficient interruption-based implementations

CONCLUSION

A novel scheme to overcome the stagnation problem of parallel-independent combinations was proposed: the cyclic coefficients feedback;

The solution is more natural than conditional transfers of weights;

For two LMS filters, the structure is equivalent to a CLMS, a VSS algorithm or a hybrid AF, depending on the cycle length;

A method to design the cycle length was developed and validated;

Simulations showed that the new algorithm can either match or outperform CLMS, transfer of coefficients and series topology under different scenarios.