Control

1 Questions

1. Why is an adaptive stepsize advantageous?
2. What is the rule of thumb regarding convergence speed? What assumptions were made to obtain this rule?
3. What interdependencies exist between signal properties / parameters and the theoretical steady-state system distance of the NLMS algorithm?
4. What two opposing quantitites help model the expected system distance over time?
5. The properties of which signals are required to compute the optimal stepsize? Why can one property only be estimated and how is this done?
6. Explain the application of adaptive filters in echo cancellation and in what why this differs from a basic system indentification. What challenges does the stepsize control face in this application?

2 Answers

1. A fixed stepsize always is a compromise between convergence speed and achievable steady-state system distance. By making the stepsize adaptive, this compromise can be avoided. Additionally, the robustness against bursty distortions is improved.
2. At initial convergence the expected system distance is reduced by 10 dB every $2N$ iterations, with N being the filter length of the adaptive filter. Assumptions: no distortion, white noise excitation, $\mu = 1$.
3. The steady-state system distance is directly proportional to the inverse Signal-to-Noise Ratio (SNR, with respect to excitation). The stepsize term works as a scaling factor with smaller stepsizes yielding smaller steady-state values.
4. Contraction parameter A and expansion parameter B.
5. An estimate of the optimum stepsize may be computed using the power of both the *disturbed* and *undisturbed* error. The power of the *disturbed* error may be directly computed on a short-term scale as this signal is easily available. The power of the *undisturbed* error must be estimated using the excitation signal and a system distance estimate. The system distance may be estimated as given on 7-31.

6. For echo cancellation the echo path between loudspeaker and microphone is identified to subtract an estimate of the echo signal from the signal to be transmitted to the other user. This system identification is performed online to be able to track system changes due to to changes in the environment. Consequently, the system identification cannot rely on a well-chosen exitation signal with good convergence properties but must utilize the speech signal fed into the system by the other user. Additionally, the disturbance is often not white but colored and instationary as this is very often speech yielding a SNR around 0 dB (double-talk). The control algorithm must be able to detect the occurence of both double-talk and system changes to find a good compromise for the stepsize.