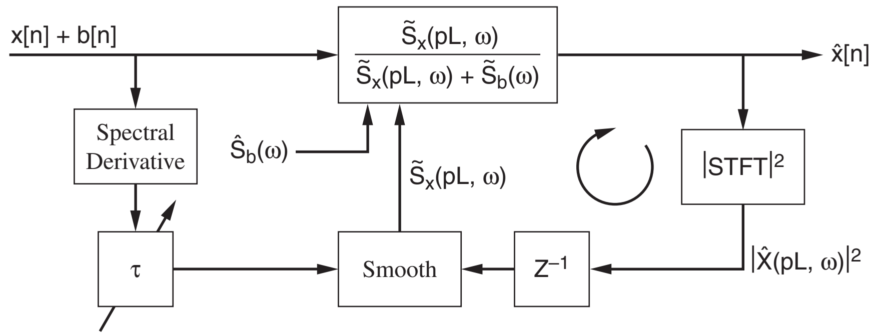

Figure 13.4 Noise-reduction Wiener filtering based on spectral change. The time-varying smoothing constant $\tau(p)$ controls the estimation of the object power spectrum, and is derived from the spectral derivative.

One approach to further recover the initial attack is to iterate the Wiener filtering on each frame; the iteration attempts to progressively improve the Wiener filter by looping back the filter output, i.e., iteratively updating the Wiener filter with a new object spectrum estimate derived from the enhanced signal. This iterative approach is indicated in Figure 13.4 by the clockwise arrow. Such an iterative process better captures the initial attack through a refined object spectrum estimate obtained from the enhanced signal and by reducing the effect of smoothing delay. Only a few iterations, however, are possible on each frame because with an increasing number of iterations, resonant bandwidths of the object spectral estimate are found empirically to become unnaturally narrow.

Example 13.3 In this example, we improve on the object signal enhancement of Example 13.2 using the adaptive and iterative Wiener filter described above. As before, a 4-ms triangular analysis window, a 1-ms frame interval, and OLA synthesis are applied. In addition to providing good temporal resolution, the short 4-ms analysis window prevents the inherent smoothing by the OLA process from controlling the Wiener filter dynamics. A 2-ms rectangular filter $f_\triangle[p]$ is selected for smoothing the spectral derivative. Figure 13.3d shows that the use of spectral change in the Wiener filter adaptation [Equation (13.16)] helps to reduce both the residual hiss artifact and improve attack fidelity, giving a cleaner and crisper synthesis. Nevertheless, the first few object components are still reduced in amplitude because, although, indeed, the spectral derivative rises, and the resulting smoothing constant falls in the object region, they do not possess the resolution nor the predictive capability necessary to track the individual object components. The iterative Wiener filter (with 2 iterations) helps to further improve the attack, as illustrated in Figure 13.3e. In addition, the uniform background residual was achieved in Figure 13.3e by allowing the background spectrum to adapt during frames declared to be background, based on an energy-based detection of the presence of speech in an analysis frame [46]. ▲

Example 13.4 Figure 13.5 shows a frequency-domain perspective of the performance of the adaptive Wiener filter based on spectral change and with iterative refinement (2 iterations). In this example, a synthetic signal consists of two FM chirps crossing one another and repeated, and the background is white Gaussian noise. As in the previous example, the analysis window duration is 4 ms, the frame interval is 1 ms, and OLA synthesis is applied. Likewise, a 2-ms rectangular filter $f_\triangle[p]$ is selected for smoothing the spectral derivative. The ability of the Wiener filter to track the FM is illustrated by spectrographic views, as well as by snapshots of the adaptive filter at three different signal transition time instants. ▲