EE110B Lab 5

In a small room with concrete walls (or other similar environment), we often notice acoustic echoes. If you do not talk very closely to a microphone (on a cell phone for example) in such an environment, the microphone will pick up echoes. The echoes are distortion and could cause many problems. In this lab, you will evaluate the effect of echoes and test a method for echo cancellation.

1) Assume that the system between the voice $x[n]$ from your mouth and the acoustic signal $y[n]$ picked up by a microphone is linear and time-invariant, and hence

$$y[n] = h[n] * x[n] = \sum_{l=1}^{L} h[l]x[n-l]. \tag{1}$$

To see the effect of the echo distortion, assume

$$x[n] = \sin(\frac{\pi}{5}n)(u[n] - u[n-10]) \tag{2}$$

and also choose the echo coefficients $h[l]$ for all $0 \le l \le 10$ randomly. Here $L = 10$. Plot $x[n]$ and $y[n]$ for $0 \le n \le 20$. Discuss the impact of $h[n]$ on $y[n]$ in relation to $x[n]$.

2) Assume the same $x[n]$ in (2) but $h[n] = 0.98^n u[n]$ which is the impulse response of a first-order feedback system.

   a) Compute and plot $y[n] = x[n] * h[n]$ for $0 \le n \le 20$ (with a large L such that $h[L]$ is negligible). Discuss the distortion effect by $h[n]$.

   b) Compute and plot $v[n] = g[n]*y[n]$ for $0 \le n \le 20$ where $g[n] = \delta[n-5] - 0.98\delta[n-6]$. Discuss the quality of $g[n]$ as an echo cancellation filter.

3) If $h[n] = a^n u[n] - b^n u[n]$ (which is the impulse response of a second-order feedback system), then its DTFT is $H(f) = \frac{1}{1-ae^{-j2\pi f}} - \frac{1}{1-be^{-j2\pi f}} = \frac{(a-b)e^{-j2\pi f}}{1-(a+b)e^{-j2\pi f}+abe^{-j4\pi f}}$. A good inverse filter of $H(f)$ has the frequency response $G(f) = 1 - (a+b)e^{-j2\pi f} + abe^{-j4\pi f}$. Assume the same $x[n]$ in (2) but $h[n] = 0.98^n u[n] - (-0.95)^n u[n]$.

   a) Compute and plot $y[n] = x[n] * h[n]$ for $0 \le n \le 20$ (with a large L such that $h[L]$ is negligible). Discuss the distortion effect by $h[n]$.

   b) Compute and plot $v[n] = g[n] * y[n]$ for $0 \le n \le 20$ with $g[n] = \delta[n] - (a+b)\delta[n-1] + ab\delta[n-2]$, $a = 0.98$ and $b = -0.95$. Discuss the quality of $g[n]$ as an echo cancellation filter.