2004 Paper 7 Question 10

Digital Signal Processing

(*a*) You have designed a digital water-level display installed on the River Cam. A sensor measures the current height of a small floating ball once every minute. In order to reduce the fluctuations that small waves would otherwise cause in the displayed value, you implemented a digital filter $y_i = 0.8y_{i-1} + 0.2x_i$, where the x_i are the measured and the y_i are the displayed water levels.

(*i*) What type of filter is this? [2 marks]

(*ii*) The standard deviation caused by small waves in the measurements is 30 mm. There is no measurable correlation between these added noise values. Calculate the standard deviation caused by small waves in the displayed water levels. [8 marks]

(*b*) Let H be a digital low-pass filter with finite impulse response $h_0, h_1, \ldots, h_7$. Let f_s be the sampling frequency. Give the impulse response $h'_0, h'_1, \ldots, h'_7$ of a filter H' with frequency response $|H'(f)| = |H(f_\mathrm{s}/2 - f)|$. [4 marks]

(*c*) A programmer cuts a block out of a digitised sound signal and applies the Discrete Fourier Transform to estimate its spectral power distribution.

(*i*) What effect distorts the resulting power spectrum? [3 marks]

(*ii*) Describe briefly *one* technique to reduce these distortions. [3 marks]