Computational Savings of Polyphase/DFT Filterbanks*

Phil Schniter

This work is produced by OpenStax-CNX and licensed under the
Creative Commons Attribution License 1.0†

Abstract

This module looks at the computational savings of the polyphase/DFT modulated filterbank implementation by comparing the number of computations performed for various methods.

This module will briefly take a look a the computational savings of the polyphase/DFT modulated filterbank implementation. We will start by looking at our standard analysis bank and then move on to compare this with our other implementation approaches.

Assume that the lowpass filter in the standard analysis bank, $H(z)$, has impulse response length N. To calculate the sub-band output vector $\{ y_k[m], y_k[m] \mid k = \{0, \ldots, M-1\} \}$ using the standard structure, we have

$$M \frac{\text{decimator outputs}}{\text{vector}} \times M \frac{\text{filter outputs}}{\text{decimator outputs}} \times (N+1) \frac{\text{multiplications}}{\text{filter output}} = M^2 (N+1) \frac{\text{multiplications}}{\text{vector}} \quad (1)$$

where we have included one multiply for the modulator. The calculations above pertain to standard (*i.e.*, not polyphase) decimation. If we implement the lowpass/downsampler in each filterbank branch with a polyphase decimator,

$$M \frac{\text{branch outputs}}{\text{vector}} \times (N+1) \frac{\text{multiplications}}{\text{branch output}} = M (N+1) \frac{\text{multiplications}}{\text{vector}} \quad (2)$$

To calculate the same output vector for the polyphase/DFT structure, we have approximately

$$1 \frac{\text{DFT}}{\text{vector}} \times \left(\frac{M}{2} \log_2 M \frac{\text{multiplications}}{\text{DFT}} \times M \frac{\text{polyphase outputs}}{\text{DFT}} \times \frac{N}{M} \frac{\text{multiplications}}{\text{polyphase output}} \right) \quad (3)$$

$$= \left(N + \frac{M}{2} \log_2 M \right) \frac{\text{multiplications}}{\text{vector}}$$

The table below gives some typical numbers. Recall that the filter length N will be linearly proportional to the decimation factor M, so that the ratio $\frac{N}{M}$ determines the passband and stopband performance.

	$M = 32,\ \frac{N}{M} = 10$	$M = 128,\ \frac{N}{M} = 10$
standard	328,704	20,987,904
standard with polyphase	10,272	163,968
polyphase/DFT	400	1,728

*Version 2.3: Sep 20, 2005 3:36 pm -0500

†http://creativecommons.org/licenses/by/1.0

Table 1