Wavelet Video Compression

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Project Objectives

- Objective: real-time wavelet video codec
- Current state of research:
  - Wavelet compression developed primarily in image processing context.
  - Zerotree algorithm has arisen as preferred quanitzation method.
  - Zerotree variants (e.g., vector zerotree) currently being proposed.

State of the Research

- Current state of research: (con’t) ...
  - Several wavelet filters have been established as suitable for image processing.
    - Filter is critical in determining transform quality and complexity.
    - Short filters (e.g., 5/3) reduces complexity significantly but does not always result in acceptable rate/distortion characteristics.

Problems to Solve

- Problems with wavelet video compression:
  - Complexity of current codecs exceed real-time constraints.
  - Motion compensation not amenable for use with wavelet transform.
    - codec still requires full transform after estimation process.
  - Hybrid wavelet / H.263 motion is inferior to pure H.263 (with DCT).

Current Approach

- Our present strategy:
  - Improve image codec to within real-time requirement.
  - Use image codec to produce intraframe video stream.
- Our approach:
  - Develop wavelet transform code with all-pass filters in a polyphase network.
  - Incorporate transform into Said/Perlman algorithm.

All-pass Filters

- All-pass polyphase filters:
  - All-pass filters are IIR a opposed to FIR for QMF filters.
  - Non-causal requirement for perfect reconstruction nullified due to finite extent of images.
  - All-pass polyphase design reduces high order QMF filter bank to 0th and 1st order filters (much lower complexity).

All-pass Filters

- All-pass polyphase filters: (con't) ...
  - 0th and 1st order all-pass polyphase filter equivalent to order 16 QMF filter with factor 5 complexity reduction for 2x2 bands.
    - (J.H.Husoy and T.A.Ramstad, March 1990).

# of bands	FIR Filter Type	
	16D	32D
2 x 2	5.34	10.67
4 x 4	9.14	18.29
8 x 8	12.80	25.60

Codec Complexity

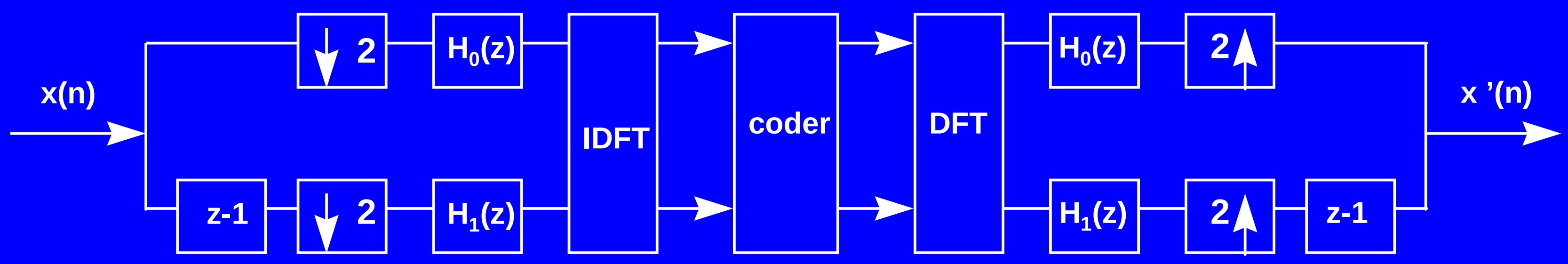
- Complexity issues:
  - For tree structured FIR NxN band filter bank:
    - $NM^2\log_2(N)$ multiplications
  - Filtering for all-pass polyphase filter:
    - $2(N-1)(M/N)M$ multiplications
  - DFT requires (e.g., for 8x8 DFT):
    - $2M^2$ non-trivial multiplications
      -
    - where NxN = no. of subbands, MxM = picture dimension,
    - and L = length of the FIR filter

Complexity Issues

- Complexity issues: (con't) ...
  - Complexity reduction from FIR filter bank to all-pass polyphase filter bank:
    - $R \;=\; 1 \;\; L \log_2(N)$
    - $\underline{2}\;\; \underline{(2\text{-}1 \,/\, N)}$
    - Previous table resulted from computation of typical values of N and L.

All-pass Filter Data Flow

- All-pass polyphase filter structure:



  - analysis/synthesis 2x2 filter bank with coder

All-pass Filter Data Flow

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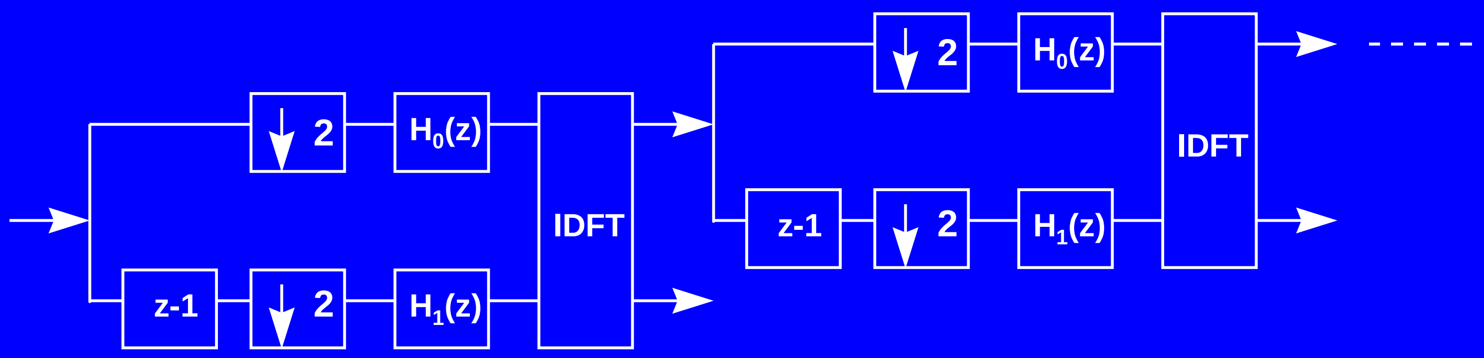

  - wavelet implementation of all-pass polyphase filters