

# Time Domain Lapped Transforms for Video Coding

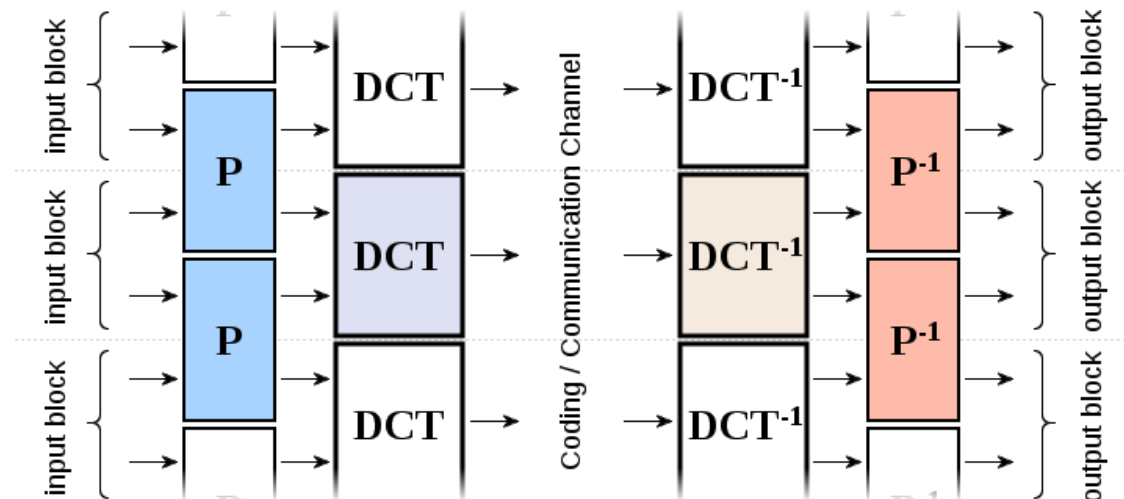
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# Lapped Transforms

- Originally proposed for video in 1989 by Malvar [1].
- $n$ -point prefilter applied along block boundaries
  - Removes spatial correlation between blocks
  - Improves coding performance of  $n$ -point DCT
- Decoder applies  $n$ -point postfilter (exact inverse)
  - Quantization error spread over adjacent blocks



# Lapped Transforms

- Prefilter makes the image “blocky”



- Postfilter “smoothes” blocking artifacts



# Lapped Transforms

- Pros:

- Larger spatial support means higher compression performance (improved coding gain)
- Non-adaptive, in-loop postfilter

subset-1	4x4	8x8	16x16
KLT	12.47 dB	13.62 dB	14.12 dB
DCT	12.42 dB	13.55 dB	14.05 dB
LT-KLT	13.35 dB	14.13 dB	14.40 dB
LT-DCT	13.33 dB	14.12 dB	14.40 dB

- Cons:

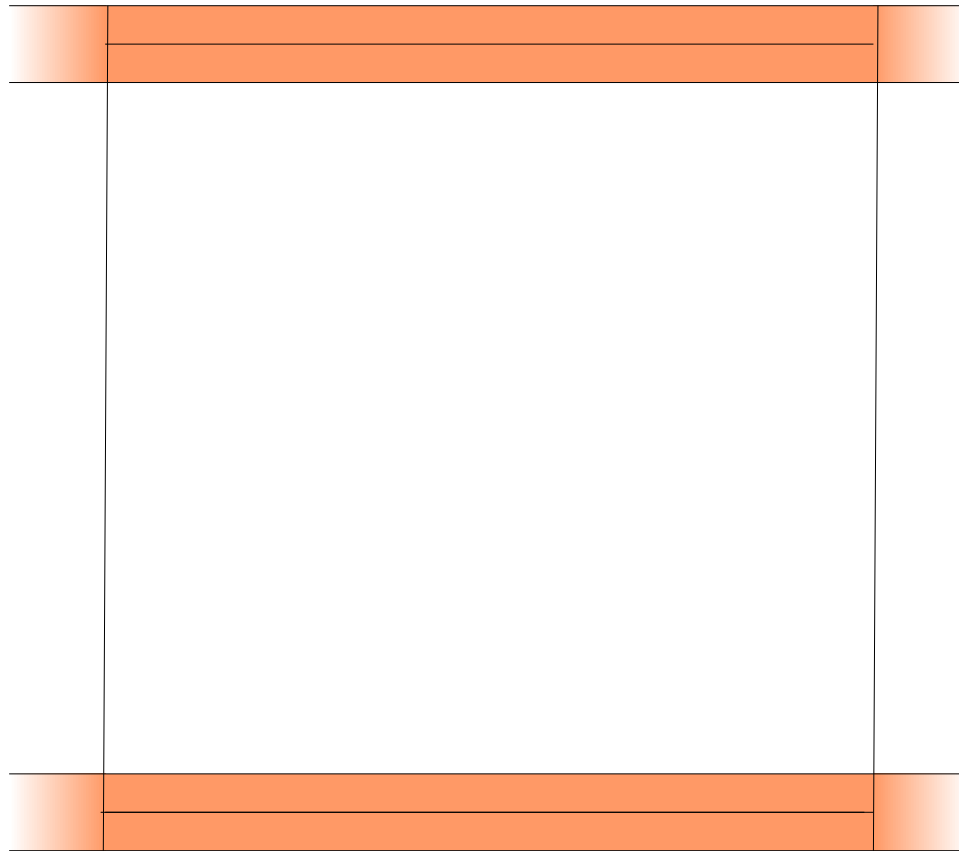
- Increased ringing on edges
- Proven coding techniques no longer work: spatial intra-prediction, intra blocks in inter frames, etc.

# Lapped Transforms

- Sizes: 4x4, 8x8, 16x16 and 32x32 (64x64 in progress)
- Lapping
  - Luma blocks larger than 4x4 use 8-point lapping on all edges
  - When splitting an 8x8 down to 4x4:
    - 8-point lapping applied to “exterior” (8x8) edges
    - 4-point lapping applied to “interior” edges
  - 4:2:0 chroma uses 4-point lapping on all edges
- Lapping size does not depend on neighbors’ block size
  - Allows for efficient (exhaustive) block size decision

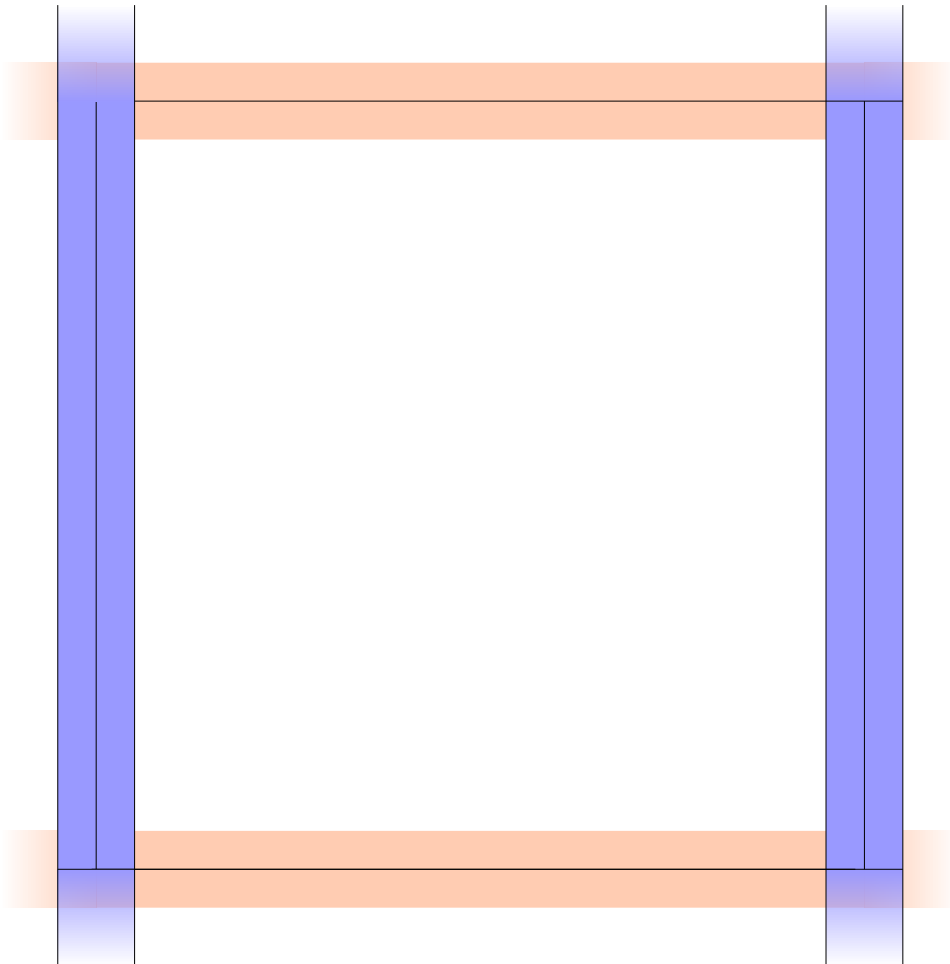
# Filter Order

- Filter top/bottom superblock edges



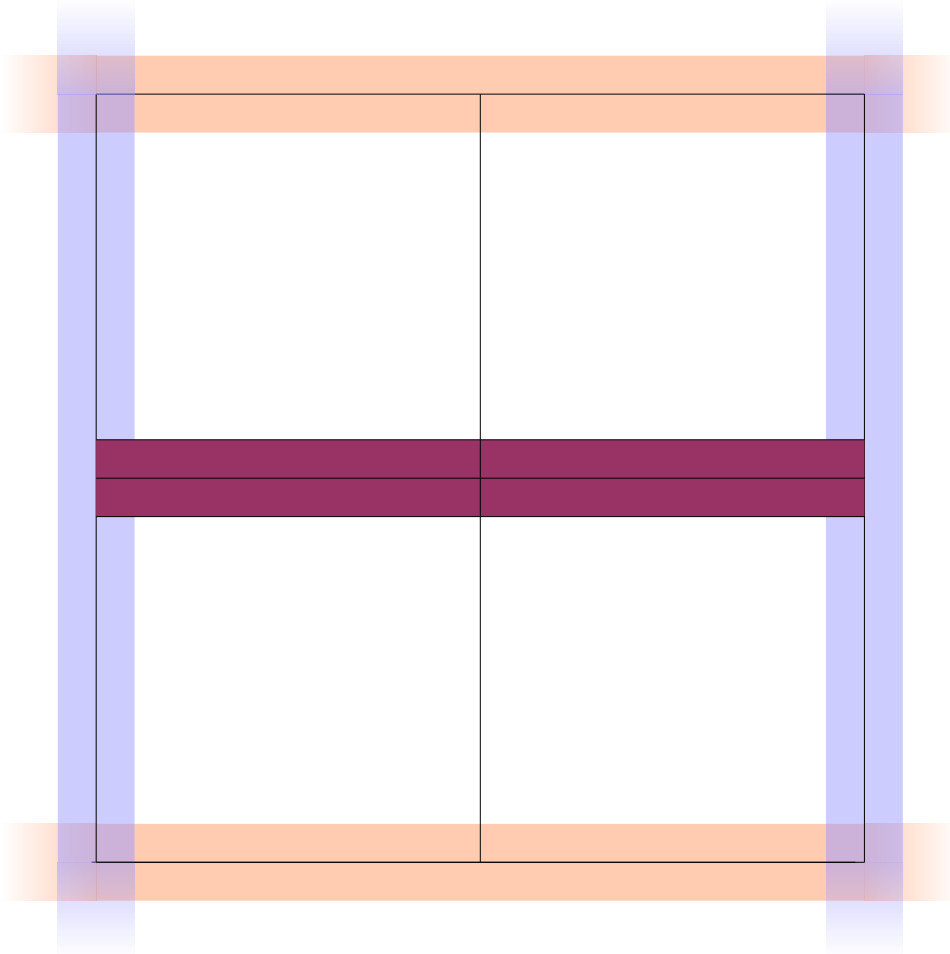
# Filter Order

- Filter left/right superblock edges



# Filter Order

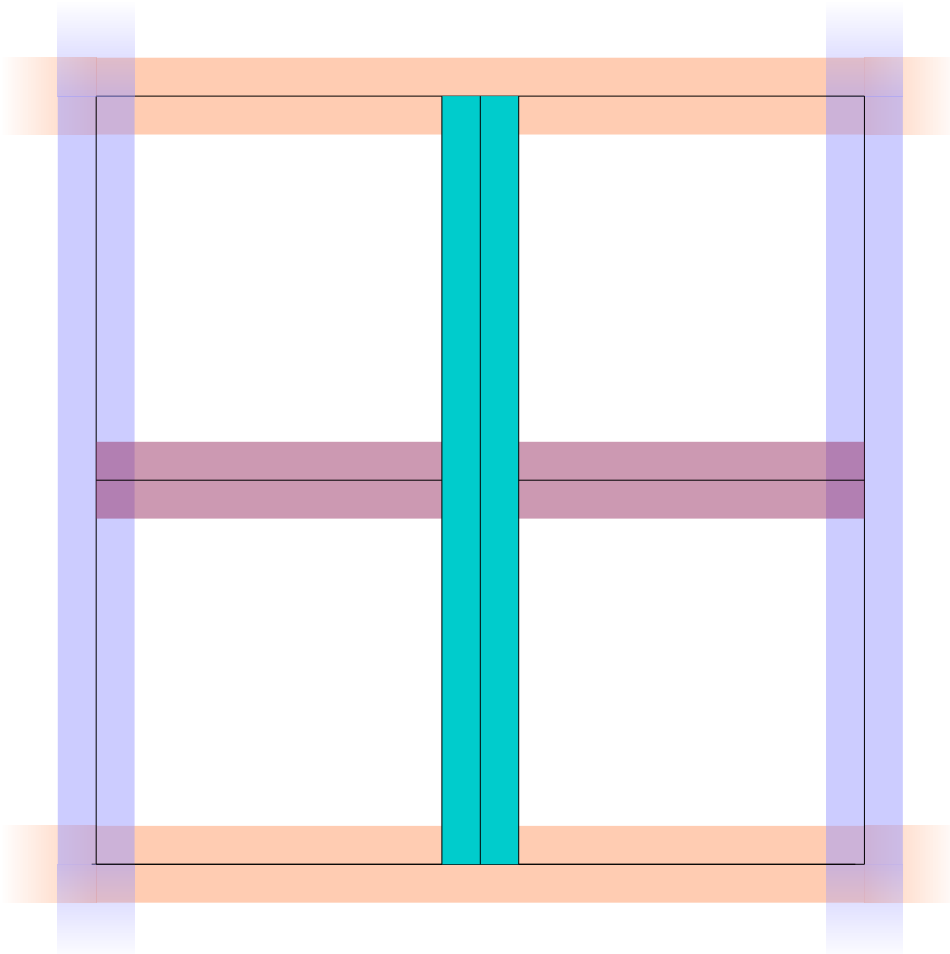
- Splitting: Filter interior edges





# Filter Order

- Splitting: Filter interior edges



# Lapped Transform Properties

- Reversible
  - $i\text{LT}(\text{fLT}(x)) == x$  for all  $x$
- Biorthogonal (not orthogonal)
  - Not all basis functions have the same magnitude
- Dynamic range expansion
  - Core DCT is orthonormal (minimum possible)
  - Pre/post-filters add a few more bits
- Pre-scaling
  - Lossy input scaled by 16 to reduce impact of rounding
  - $16 \times 16$  and above no longer fit in 16 bits

Questions?