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Residue scan for intra transform skip mode

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Overall summary

- The energy of residual is usually proportional to its prediction distance.
  - Thus, the energy distribution of the residue is usually reverse of that of the transform coefficients.

- Proposal: Reverse the residue scan order for transform skip mode from the transform scan order
  - Can be easily implemented at the scaling stage.
  - Changed only two lines in HM software
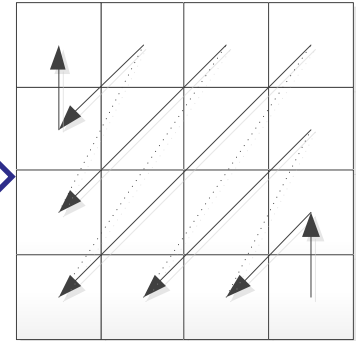 - Significant gains are observed for Class F sequences

BD-rate	HE10-AI	HE10-RA	HE10-LB
Class F	-1.6%	-1.1%	-0.7%
Others	-0.2%	-0.1%	0.0%

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Intra Residue Energy Distribution

- Diagonal scan:
  - When transform on: Energy decreases from top-left corner to right-bottom corner.
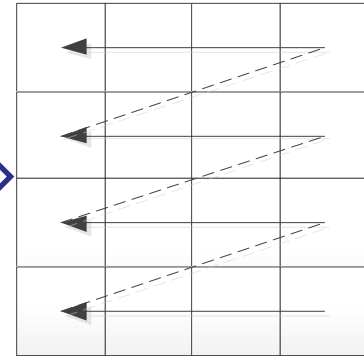 - When transform skipped: Energy increases from top-left corner to right-bottom corner.

  Inverse scan

- Horizontal scan:
  - When transform on: Energy decreases from top rows to bottom rows.
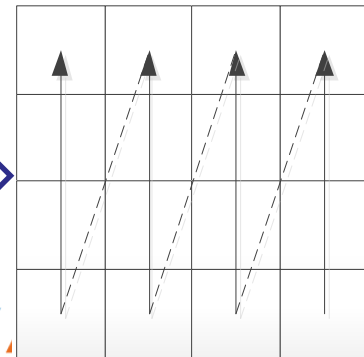 - When transform skipped: Energy increases from top rows to bottom rows.

  Inverse scan

- Vertical scan:
  - When transform on: Energy decreases from left columns to right columns.
  - When transform skipped: Energy increases from left columns to right columns.

  Inverse scan

Implementation

- Can be done easily at the scaling stage

- HM software
  - Only need to modify two code lines: one in the forward scaling and one in the backward scaling

For example, the backward scaling modification:

pResidual[j * uiStride + k] = (plCoef[j * width + k] + iAdd) >> iTransformShift

pResidual[j * uiStride + k] = (plCoef[(height-1-j) * width + (width-1-k)] + iAdd) >> iTransformShift

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Simulation Results

- Anchor: HM-7.0

- HE10 common test conditions

	All Intra HE10			Random Access HE10			Low delay B HE10		
	Y	U	V	Y	U	V	Y	U	V
Class A	0.0%	-0.3%	-0.2%	0.0%	-0.2%	0.0%			
Class B	-0.1%	-0.3%	-0.4%	0.0%	-0.4%	-0.5%	0.0%	0.1%	-0.1%
Class C	-0.4%	-0.9%	-1.1%	-0.2%	-0.7%	-1.0%	0.0%	-0.2%	-0.2%
Class D	-0.5%	-1.1%	-1.4%	-0.2%	-0.6%	-1.3%	0.0%	0.1%	-0.6%
Class E	-0.2%	-0.4%	-0.4%				-0.1%	-0.7%	-0.7%
Overall	-0.2%	-0.6%	-0.7%	-0.1%	-0.5%	-0.7%	0.0%	-0.1%	-0.4%
	-0.2%	-0.6%	-0.7%	-0.1%	-0.5%	-0.7%	0.0%	-0.1%	-0.3%
Class F	-1.6%	-2.1%	-2.2%	-1.1%	-1.4%	-1.8%	-0.7%	-0.7%	-0.3%
Enc Time[%]	100%			100%			100%		
Dec Time[%]	99%			99%			100%		

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Conclusion

- Reverse scan order for intra transform skip mode
  - Can be easily implemented at scaling stage by modifying only two code lines
  - Simulation results

BD-rate	HE10-AI	HE10-RA	HE10-LB
Class F	-1.6%	-1.1%	-0.7%
Others	-0.2%	-0.1%	0.0%

  - Suggest to be adopted in HEVC

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Backup

doc.	company		algorithm	performance
J0053	MediaTek		inversed scan for intra transform skip; modified two code lines only	class F: 1.6%, 1.1%, 0.7% gain for HE10-AI/RA/LB others: 0.2%, 0.1%, 0.0% gain for HE10-AI/RA/LB
J0093	RIM			
J0202	ETRI	Algo. 1	only diagonal scan used for intra transform skip mode	class F: 0.3% gain for HE10-AI Others: 0.0% gain for HE10-AI
		Algo. 2	for intra transform skip mode, Hor. Scan is used for Ver. Scan, and Ver. Scan is used for Hor. Scan. (i.e., swap Hor and Ver scan for transform skip mode)	class F: 0.9%, 0.7%, 0.3% gain for HE10-AI/RA/LB others: 0.0%, 0.0%, 0.0% gain for HE10-AI/RA/LB.
J0212	Panasonic			
J0313	Mitsubishi	Algo. 1		
		Algo. 2	Expand the swap to other intra prediction modes.	class F: 1.0%, 0.7%, 0.4% gain for HE10-AI/RA/LB others: 0.1%, 0.0%, 0.0% gain for HE10-AI/RA/LB

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