JCTVC-H0276

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CE8.e.1: Offset Coding in SAO

Chih-Ming Fu, Yu-Wen Huang, Shawmin Lei (MediaTek)
In Suk Chong, Marta Karczewicz (Qualcomm)

Presented by Yu-Wen Huang
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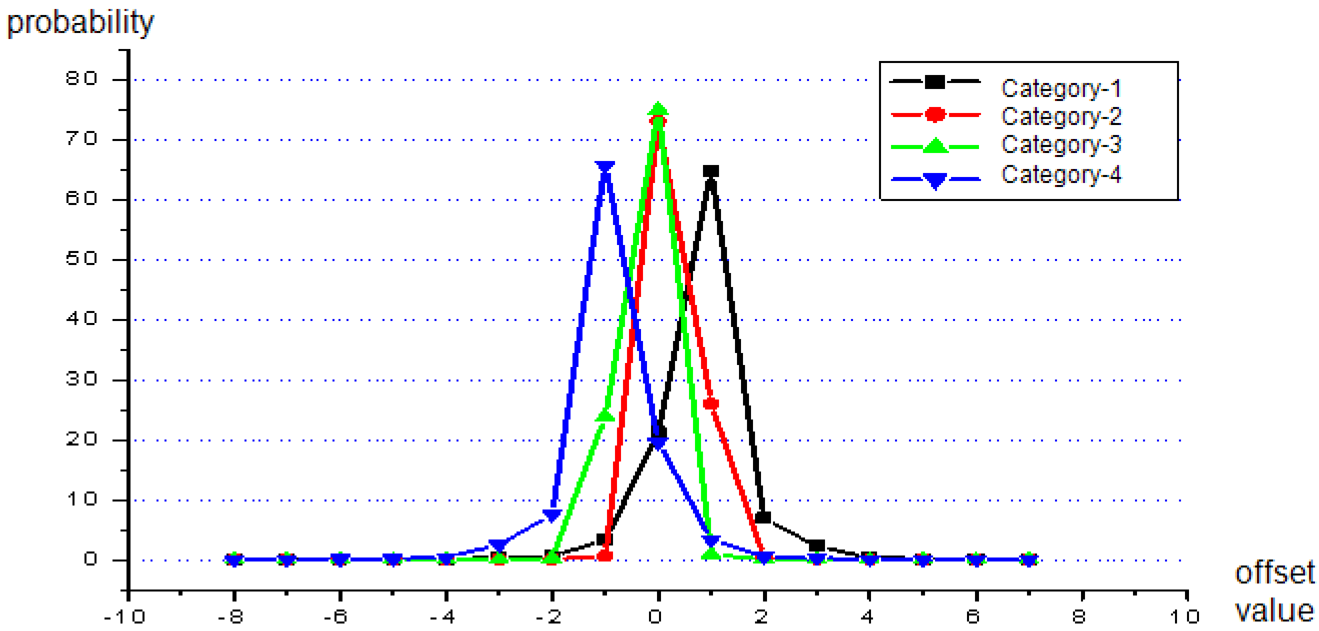
Overall Summary

- In HM-5.0, zero offset has the shortest codeword, which does not fit the offset distribution well
- New offset coding for SAO
  - Allow offset prediction
  - Redesign the offset codewords according to edge offset categories when offset prediction is not used
- Results
  - 0.1% luma bit rate reduction, 0.2% chroma bit rate reduction
  - No impact on run time
  - Significantly reduce salt and pepper noises in rare cases as reported in JCTVC-H0434
  - Totally remove salt and pepper noises when combined with a non-normative method to constrain edge offset ranges

Edge Offset Distribution

- Category-dependent
  - Category-1 (valley) prefers positive offsets
  - Category-4 (peak) prefers negative offsets
  - Not always zero-centered



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Proposed Offset Coding

- Edge offset (EO)
  - If the left region has the same depth and applies EO
    - Category-1 predictor: left region category-1
    - Category-2 predictor: left region category-2
    - Category-3 predictor: category-2 with inverse sign
    - Category-4 predictor: category-1 with inverse sign
  - Otherwise, use new category-dependent codewords
    - If (offset – b)< 0 , index = –2 (offset – b) – a
      otherwise , index = 2 (offset – b) + a – 1
    - Encode the index by unsigned exp-Golomb code

EO category	a	b
1 (valley)	1	1
2	0	0
3	1	0
4 (peak)	0	1

- Band offset (BO):
  - The 2nd band is predicted by the 1st band,
  - The 16th band is predicted by the 15th band

Simulation Results

- Anchor: JCTVC-G1200
- Minor coding gain in both luma and chroma
- No run time change

	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V
Class A (8bit)	0.0%	-0.1%	-0.1%	-1.1%	-2.2%	-2.4%
Class B	0.0%	0.0%	0.0%	-0.6%	-2.4%	-3.6%
Class C	0.0%	-0.1%	-0.1%	-0.7%	-2.6%	-3.6%
Class D	0.0%	-0.1%	-0.1%	-0.5%	-1.8%	-2.4%
Class E	0.0%	0.0%	-0.1%	-0.9%	-4.2%	-3.9%
Overall	**0.0%**	**-0.1%**	**-0.1%**	**-0.7%**	**-2.6%**	**-3.3%**
	0.0%	-0.1%	-0.1%	-0.7%	-2.6%	-3.2%
Class F	0.0%	0.0%	0.0%	-2.9%	-3.7%	-5.5%
Enc Time[%]		100%			101%	
Dec Time[%]		100%			103%	

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A (8bit)	0.0%	0.0%	-0.2%	-1.4%	-2.6%	-3.3%
Class B	0.0%	0.0%	-0.1%	-2.0%	-5.6%	-5.8%
Class C	-0.1%	-0.1%	-0.2%	-1.0%	-4.2%	-5.5%
Class D	0.0%	-0.3%	-0.2%	-0.4%	-2.3%	-2.8%
Class E						
Overall	**-0.1%**	**-0.1%**	**-0.2%**	**-1.2%**	**-4.0%**	**-4.6%**
	-0.1%	-0.1%	-0.2%	-1.2%	-4.0%	-4.6%
Class F	-0.1%	-0.1%	-0.1%	-5.3%	-6.6%	-9.5%
Enc Time[%]		100%			100%	
Dec Time[%]		100%			102%	

	Low Delay B HE			Low Delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	0.0%	0.2%	0.3%	-2.9%	-9.1%	-10.1%
Class C	-0.1%	-0.1%	0.0%	-1.9%	-7.5%	-11.1%
Class D	-0.1%	0.0%	-0.1%	-0.9%	-4.0%	-5.4%
Class E	0.0%	0.2%	-0.3%	-3.6%	-15.3%	-14.2%
Overall	**-0.1%**	**0.1%**	**0.0%**	**-2.3%**	**-8.6%**	**-9.9%**
	-0.1%	0.1%	0.0%	-2.3%	-8.5%	-9.9%
Class F	-0.1%	0.0%	-0.3%	-9.1%	-12.4%	-16.2%
Enc Time[%]		100%			100%	
Dec Time[%]		100%			103%	

	Low Delay P HE			Low Delay P LC		
	Y	U	V	Y	U	V
Class A						
Class B	-0.1%	-0.1%	-0.1%	-10.7%	-12.2%	-13.6%
Class C	-0.1%	-0.1%	-0.3%	-6.4%	-9.9%	-12.9%
Class D	-0.1%	-0.5%	-0.7%	-3.6%	-6.4%	-7.3%
Class E	-0.2%	0.0%	-0.5%	-11.5%	-19.8%	-18.8%
Overall	**-0.1%**	**-0.2%**	**-0.4%**	**-8.0%**	**-11.6%**	**-12.8%**
	-0.1%	-0.2%	-0.4%	-8.0%	-11.5%	-12.7%
Class F	-0.1%	0.2%	-0.1%	-10.3%	-13.2%	-16.4%
Enc Time[%]		101%			100%	
Dec Time[%]		101%			104%	

Solution to Salt and Pepper Noise Problem

- In rare cases, salt and pepper noises can be observed as reported in JCTVC-H0434
- We propose a simple encoder-only non-normative solution to remove all potential salt and pepper noises
  - To limit the offset ranges as follows

	EO Min Value		EO Max Value	
EO Category	1 (valley)	2	3	4 (peak)
Constraint	-1	0	0	1

Combined Results

- Anchor: JCTVC-G1200
- Very minor coding gain in both luma and chroma
- No run time change

	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V
Class A (8bit)	0.0%	-0.1%	-0.1%	-1.1%	-2.2%	-2.4%
Class B	0.0%	0.0%	0.0%	-0.6%	-2.4%	-3.6%
Class C	0.0%	0.0%	-0.1%	-0.7%	-2.6%	-3.6%
Class D	0.0%	-0.1%	-0.1%	-0.5%	-1.8%	-2.4%
Class E	0.0%	0.0%	-0.1%	-0.9%	-4.2%	-3.9%
Overall	**0.0%**	**0.0%**	**-0.1%**	**-0.7%**	**-2.6%**	**-3.3%**
	0.0%	0.0%	-0.1%	-0.7%	-2.6%	-3.2%
Class F	0.0%	0.0%	0.0%	-2.9%	-3.7%	-5.5%
Enc Time[%]		101%			101%	
Dec Time[%]		100%			103%	

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A (8bit)	0.0%	-0.1%	-0.2%	-1.4%	-2.6%	-3.3%
Class B	-0.1%	0.0%	0.0%	-2.0%	-5.5%	-5.7%
Class C	-0.1%	0.0%	-0.1%	-1.0%	-4.1%	-5.5%
Class D	0.0%	-0.3%	-0.3%	-0.4%	-2.3%	-2.7%
Class E						
Overall	**-0.1%**	**-0.1%**	**-0.1%**	**-1.2%**	**-3.9%**	**-4.5%**
	-0.1%	-0.1%	-0.1%	-1.2%	-3.9%	-4.6%
Class F	-0.1%	0.0%	0.0%	-5.3%	-6.6%	-9.5%
Enc Time[%]		100%			100%	
Dec Time[%]		100%			103%	

	Low Delay B HE			Low Delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	0.0%	0.3%	0.4%	-2.9%	-8.9%	-9.9%
Class C	0.0%	0.0%	0.0%	-1.9%	-7.4%	-11.1%
Class D	-0.1%	-0.1%	-0.4%	-0.8%	-3.6%	-5.2%
Class E	0.0%	0.6%	-0.6%	-3.5%	-15.4%	-14.0%
Overall	**0.0%**	**0.2%**	**-0.1%**	**-2.2%**	**-8.4%**	**-9.8%**
	0.0%	0.2%	-0.1%	-2.2%	-8.4%	-9.8%
Class F	-0.2%	0.0%	-0.2%	-9.2%	-12.3%	-16.1%
Enc Time[%]		100%			100%	
Dec Time[%]		100%			103%	

	Low Delay P HE			Low Delay P LC		
	Y	U	V	Y	U	V
Class A						
Class B	-0.1%	0.1%	-0.1%	-10.7%	-12.1%	-13.3%
Class C	0.0%	0.1%	-0.2%	-6.4%	-9.7%	-12.8%
Class D	-0.1%	-0.3%	-0.6%	-3.7%	-6.2%	-7.3%
Class E	0.0%	-0.3%	0.0%	-11.5%	-20.3%	-18.8%
Overall	**0.0%**	**-0.1%**	**-0.2%**	**-8.0%**	**-11.6%**	**-12.7%**
	0.0%	-0.1%	-0.2%	-8.0%	-11.5%	-12.6%
Class F	-0.1%	0.5%	0.2%	-10.2%	-13.3%	-16.1%
Enc Time[%]		100%			100%	
Dec Time[%]		99%			104%	

HM-5.0, BasketballDrive, HE-LDB, QP37, POC 423

Test, BasketballDrive, HE-LDB, QP37, POC 423

HM-5.0, BQMall, HE-LDB, QP37, POC 29

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Test, BQMall, HE-LDB, QP37, POC 29

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HM-5.0, BQMall, HE-LDB, QP37, POC 102

Test, BQMall, HE-LDB, QP37, POC 102

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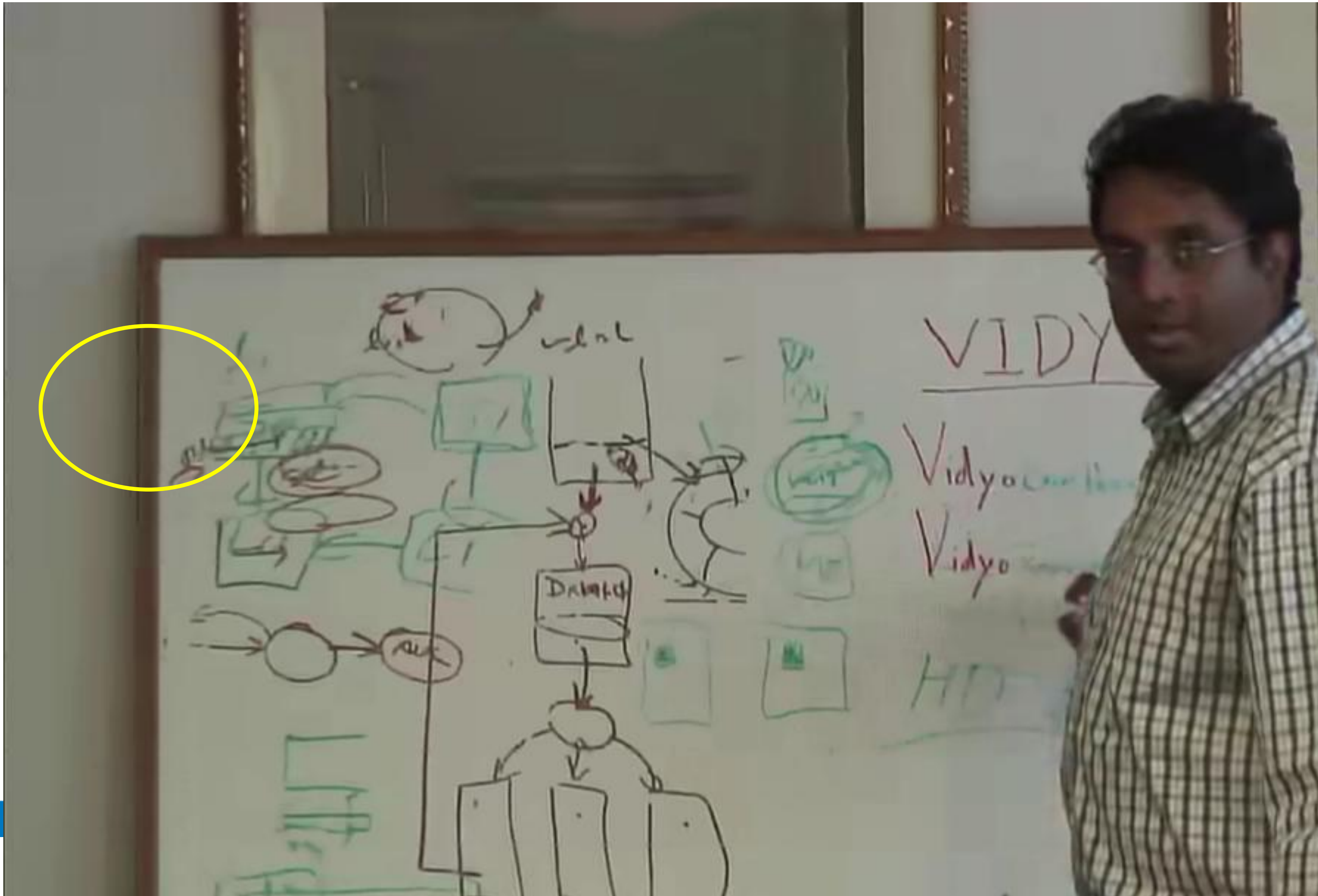
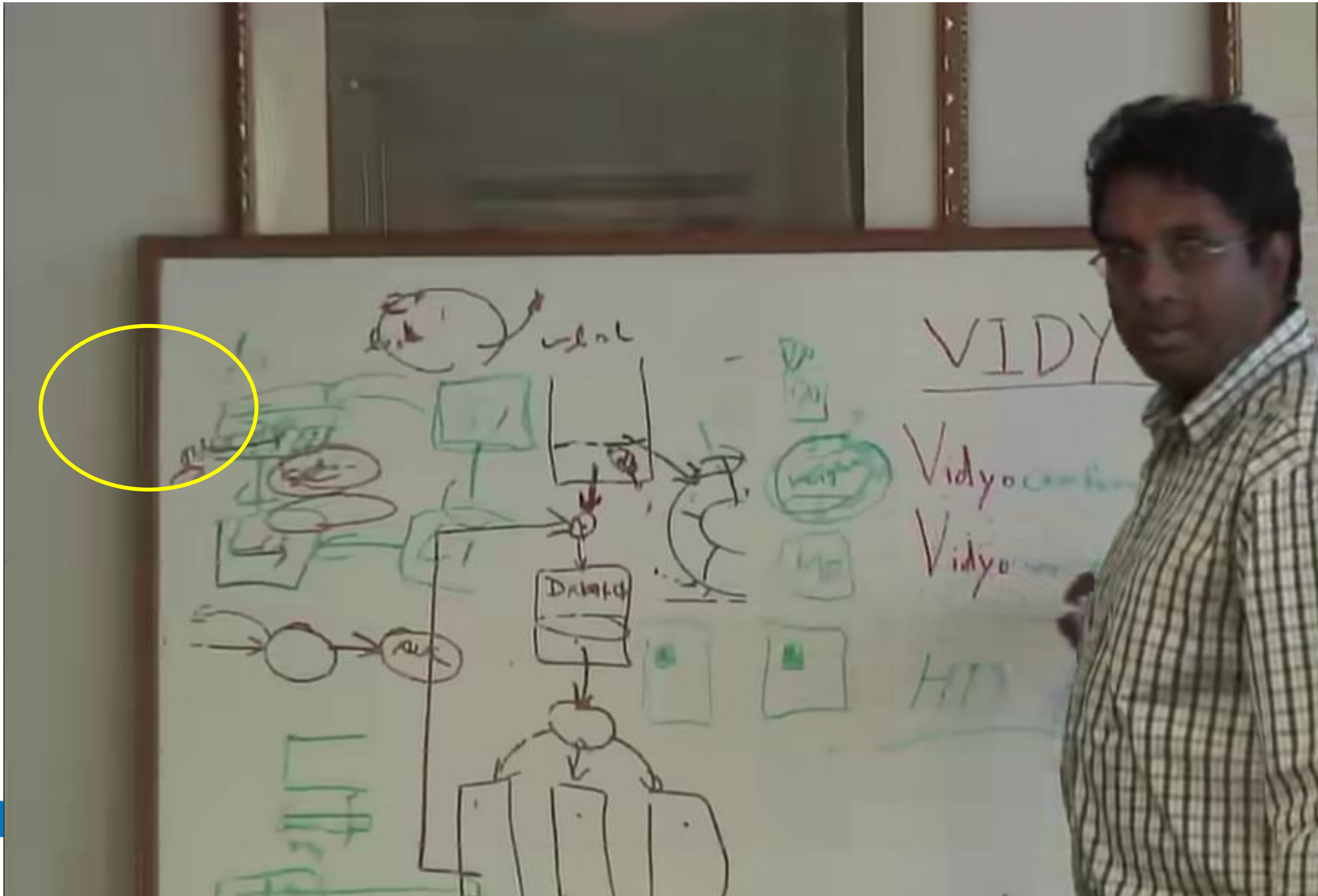
HM-5.0, Vidyo3, HE-LDB, QP37, POC 226



Test, Vidyo3, HE-LDB, QP37, POC 226



Conclusion

- New offset coding
  - Minor objective coding gain
  - Reduce salt and pepper noises
- Encoder-only non-normative edge offset range constraints
  - Very minor impact on objective coding efficiency
  - Totally prevent potential salt and pepper noises