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CE4-related: On simplification for GEO weight derivation

Yucheng Sun, Fangdong Chen, Li Wang

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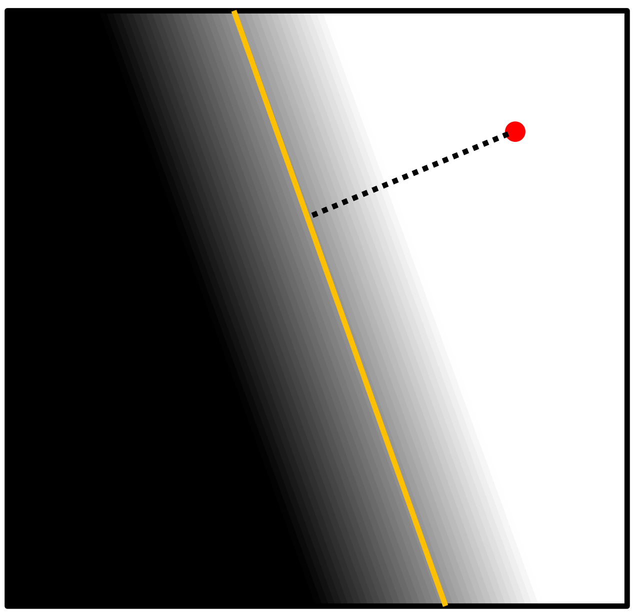
First Choice for Security Professionals

Outline

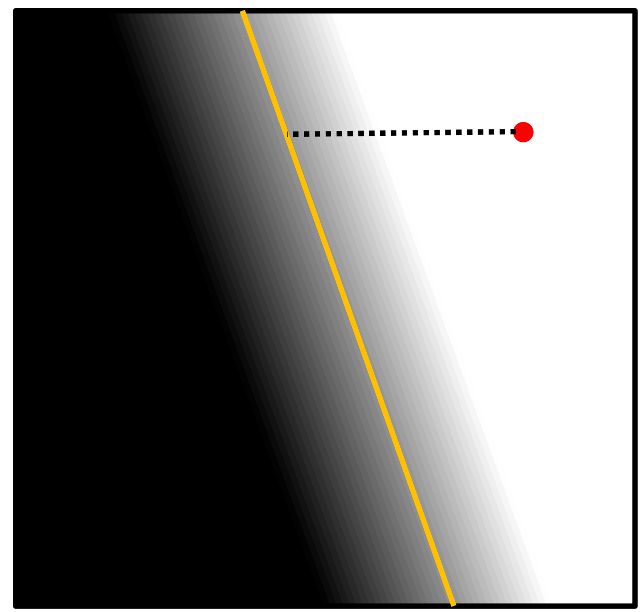
- Motivation
- Proposed Method
- Harmonized with other tools
- Experimental Results
- Conclusion

Motivation

- Simplify GEO distance calculation
  - Change distance calculation obeying same principle



Current GEO



Proposed

Motivation

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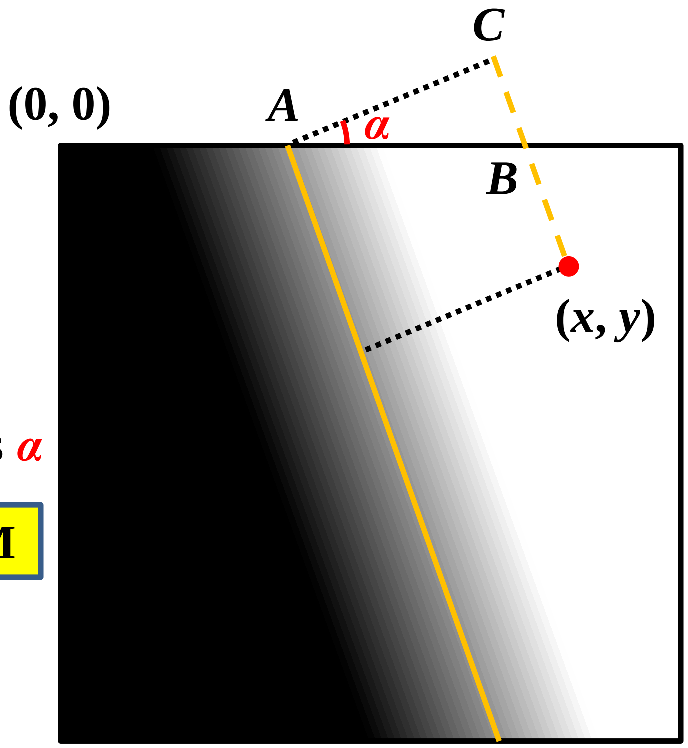
- Current GEO distance calculation
  - A is fixed when angle and step is fixed
    - Set as $(m, 0)$
  - B is decided by pixel position
    - B is $(x - y * \tan \alpha, 0)$
    - DistFromLine = $\boldsymbol{AC} = \boldsymbol{AB} * \cos \alpha$

$$= (x - y * \tan \alpha - m) * \cos \alpha$$

$$= x * \cos \alpha - y * \sin \alpha - \mathbf{M}$$



Current GEO

Motivation

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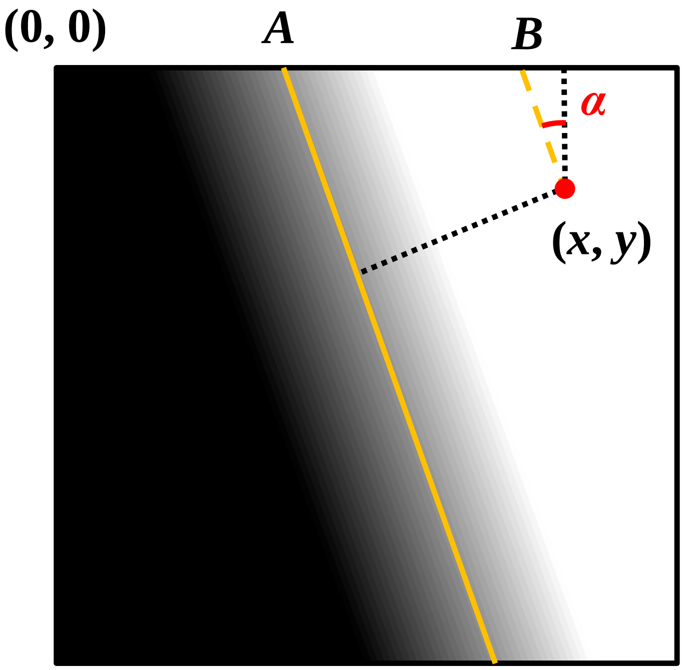
- Proposed distance calculation
  - A is fixed when angle and step is fixed
    - Set as (m, 0)
  - B is decided by pixel position
    - B is ($x - y * \tan \alpha$, 0)
    - DistFromLine = A $= x - y * \tan \alpha - m$



Proposed

Motivation

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- Current GEO
  - DistFromLine = $x * \cos\alpha - y * \sin\alpha - \mathbf{M}$
- JVET-P0264
  - DistFromLine = $x * \cos\alpha - y * \sin\alpha - \mathbf{M} = \cos\alpha \,\mathbf{*}\, (x - y * \tan\alpha) - \mathbf{M}$
  - When $\tan\alpha$ is $1 : 2^N$ or $2^N : 1$
    - DistFromLine = $\cos\alpha \,\mathbf{*}\, (x - y \ll N) - \mathrm{M}$
- Proposed
  - DistFromLine = $x - y * \tan\alpha - \boldsymbol{m}$
  - When combined with **JVET-P0264**
    - DistFromLine = $x - y \ll N - \boldsymbol{m}$ ***Note that this is not in current proposal***

Proposed Method

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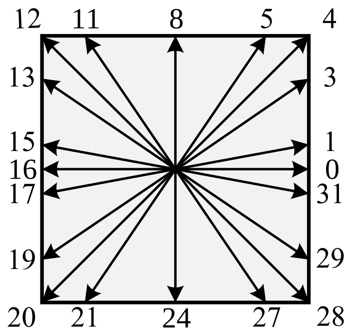
- Intra mode is already store tan value for angular modes

0	0	0	0	0	0	0	0	0	0	0	2	4	6	8	8	8	8	8	8	8	8	8	8
								0	0	0	1	2	4	6	8	8	8	8	8	8	8	8	8
								0	0	0	0	2	4	6	7	8	8	8	8	8	8	8	8
								0	0	0	0	1	3	5	7	8	8	8	8	8	8	8	8
								0	0	0	0	1	2	4	6	8	8	8	8	8	8	8	8
								0	0	0	0	0	1	3	5	7	8	8	8	8	8	8	8
								0	0	0	0	0	1	3	5	7	8	8	8	8	8	8	8
								0	0	0	0	0	0	2	4	6	7	8	8	8	8	8	8
								0	0	0	0	0	0	1	3	5	7	8	8	8	8	8	8
								0	0	0	0	0	0	1	2	4	6	8	8	8	8	8	8
								0	0	0	0	0	0	0	2	4	6	7	8	8	8	8	8
								0	0	0	0	0	0	0	1	3	5	7	8	8	8	8	8
								0	0	0	0	0	0	0	1	2	4	6	8	8	8	8	8
								0	0	0	0	0	0	0	0	1	3	5	7	8	8	8	8
								0	0	0	0	0	0	0	0	1	3	5	7	8	8	8	8
								0	0	0	0	0	0	0	0	0	2	4	6	7	8	8	8
								0	0	0	0	0	0	0	0	0	1	3	5	7	8	8	8

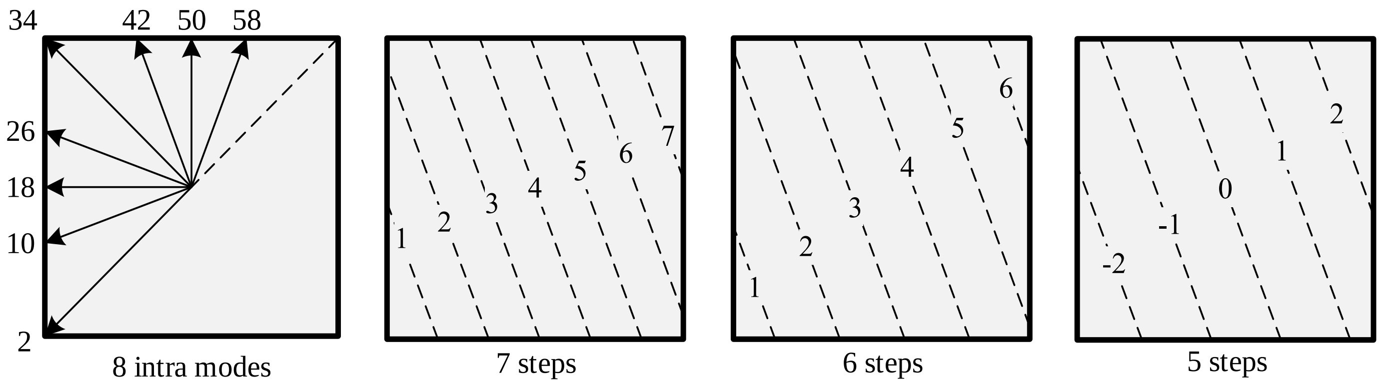
Reuse intra mode angle

Proposed Method

- current GEO modes with 64 modes
  - Pick specific angles rather than uniform
  - Remove some redundant steps
    - 0° 45° 90° 135°



- 3 tests
  - Test 1 with 56 modes including 8 angles and 7 steps
  - Test 2 with 48 modes including 8 angles and 6 steps
  - Test 3 with 40 modes including 8 angles and 5 steps



Proposed Method

Table 8-12 - Look-up table Dis for derivation of geometric partitioning distance.

idx	0	1	2	3	4	5	8	11	12	13	14	15
Dis[idx]	64	63	59	53	45	36	0	-36	-45	-53	-59	-63
idx	16	17	18	19	20	21	24	27	28	29	30	31
Dis[idx]	-64	-63	-59	-53	-45	-36	0	36	45	53	59	63

- Reduce 4 tables from spec

Table 8-10 – Specification of the angleIdx and distanceIdx values based on the merge_geo_idx value.

merge_geo_idx	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
angleIdx	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4
distanceIdx	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	1	2	3
merge_geo_idx	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**
angleIdx	5	5	5	5	8	8	8	11	11	11	11	12	12	12	13	13	13	13
distanceIdx	0	1	2	3	1	2	3	0	1	2	3	1	2	3	0	1	2	3
merge_geo_idx	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
angleIdx	14	14	14	14	15	15	15	15	16	16	16	17	17	17	18	18	18	19
distanceIdx	0	1	2	3	0	1	2	3	1	2	3	1	2	3	1	2	3	1
merge_geo_idx	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**
angleIdx	19	19	20	20	20	21	21	21	24	24	24	27	27	27	28	28	28	29
distanceIdx	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1
merge_geo_idx	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**										
angleIdx	29	29	30	30	30	31	31	31										
distanceIdx	2	3	1	2	3	1	2	3										

Table 8-13 - Filter weight look-up table GeoFilter for derivation of geometric partitioning filter weights.

idx	0	1	2	3	4	5	6	7	8	9	10	11	12	13
GeoFilter[idx]	4	4	4	4	5	5	5	5	5	5	5	6	6	6
idx	14	15	16	17	18	19	20	21	22	23	24	25	26	
GeoFilter[idx]	6	6	6	6	7	7	7	7	7	7	7	7	8	

Table 8-11 – Specification of the step distance stepDis according to the values of whRatio and angleN.

whRatio	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
angleN	0	1	2	3	4	5	6	7	8	0	1	2	3	4	5	6	7	8
stepDis[whRatio][angleN]	96	119	135	146	149	146	135	119	96	96	143	184	217	240	252	253	244	224
whRatio	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3
angleN	0	1	2	3	4	5	6	7	8	0	1	2	3	4	5	6	7	8
stepDis[whRatio][angleN]	96	193	282	359	421	465	490	495	480	96	293	478	643	783	891	963	997	992

Proposed Method

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- Weight derivation

GEO scheme

The value of the following variables are set:

- wIdx is set to log2(nCbW),
- hIdx is set to log2(nCbH),
- whRatio is set to (wIdx >= hIdx) ? wIdx – hIdx : hIdx – wIdx
- scaleIdx is set to (wIdx >= hIdx) ? hIdx - 3 : wIdx - 3
- displacementX is set to angleIdx
- displacementY is set to (displacementX + 8)%32
- angleN is set as following:

  angleN = (wIdx >= hIdx) ? (angleIdx >> 3 & 1) ? angleIdx % 8 : 8 - angleIdx % 8

  : (angleIdx >> 3 & 1) ? 8 – angleIdx % 8 : angleIdx % 8
- rho is set to the following value using the look-up tables denoted as stepDis and Dis, specified in Table 8-11 and Table 8-12:

  rho = distanceIdx* (stepDis[whRatio][angleN] << scaleIdx)

  + (Dis[displacementX]<<wIdx) + (Dis[displacementY] << hIdx) .

The variable weightIdx and weightIdxAbs are calculated using the look-up table Table 8-12 with x = 0..nCbW – 1 and y = 0..nCbH – 1 as following:

weightIdx = ((x<<1) + 1)*Dis[displacementX] + ((y<<1) + 1))*Dis[displacementY] – rho.

weightIdxAbs = Clip3(0, 26, (abs(weightIdx) + 4) >> 3).

The variable partIdx is set to weightIdx > 0, if x is equal to 0 and y is equal to nCbH – 1

The value of sampleWeight$_L$[x][y] with x = 0..nCbW – 1 and y = 0..nCbH – 1 is set according to Table 8-13 denoted as GeoFilter:

sampleWeight$_L$[x][y] = weightIdx <= 0 ? GeoFilter[weightIdxAbs] : 8 – GeoFilter[weightIdxAbs]

Proposed scheme

– If geo_flag is equal to 1, the following applies:

usefulsize = (nTbW - 1) << 5) + (abs(intraPredAngle) * (nTbH - 1)

– If intraPredAngle is less than 0, the following applies:

usefulcenter = ((32 - abs(intraPredAngle) * nTbH) << 1) + usefulsize - 64

ref[x] = Clip3(0, 8, ((x << 1) - ((((step * (usefulsize - 64)) + (usefulcenter << 2) + 64) >> 7))), with x = -nTbH..nTbW + 1

– Otherwise,

usefulcenter = (((32 + abs(intraPredAngle)) << 1) + usefulsize) - 64

ref[x] = Clip3(0, 8, ((x << 1) - ((((step * (usefulsize - 64)) + (usefulcenter << 2) + 64)) >> 7))), with x = 0.. nTbW << 1

– If geo_flag is equal to 1, the following applies:

usefulsize = (nTbH - 1) << 5) + (abs(intraPredAngle) * (nTbW - 1)

– If intraPredAngle is less than 0, the following applies:

usefulcenter = (((1 << size_scale) - abs(intraPredAngle) * nTbW) << 1) + usefulsize - 64)

ref[x] = Clip3(0, 8, ((x << 1) - ((((step * (usefulsize - 64)) + (usefulcenter << 2) + 64) >> 7))), with x = -nTbW..nTbH + 1

– Otherwise,

usefulcenter = ((((1 << size_scale) + abs(intraPredAngle)) << 1) + usefulsize) - 64)

ref[x] = Clip3(0, 8, ((x << 1) - ((((step * (usefulsize - 64)) + (usefulcenter << 2) + 64) >> 7))), with x = 0.. nTbH << 1

Harmonized with other tools

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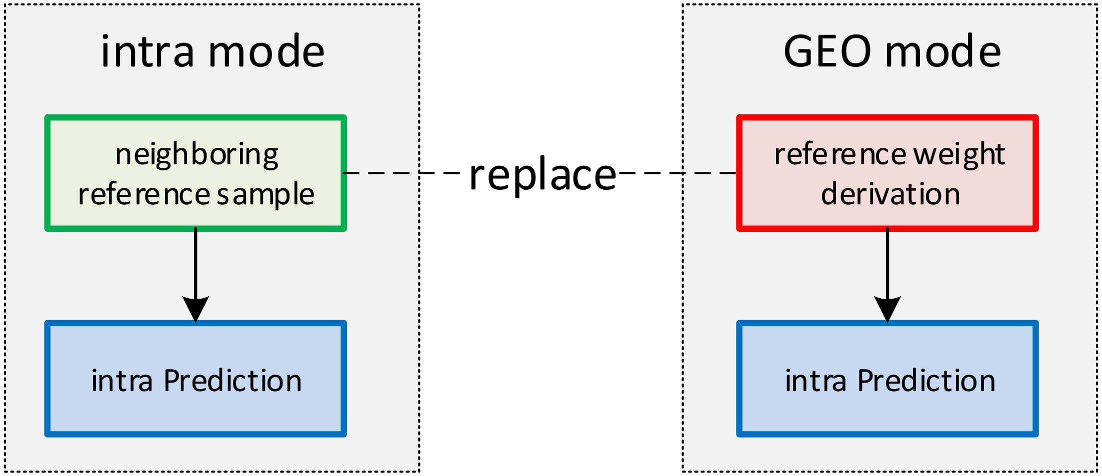
- Harmonized with intra mode
  - Replace neighbouring reference sample fetching with GEO reference weight derivation
  - Saving area for GEO weight derivation by reusing intra prediction core calculation



Harmonized with other tools

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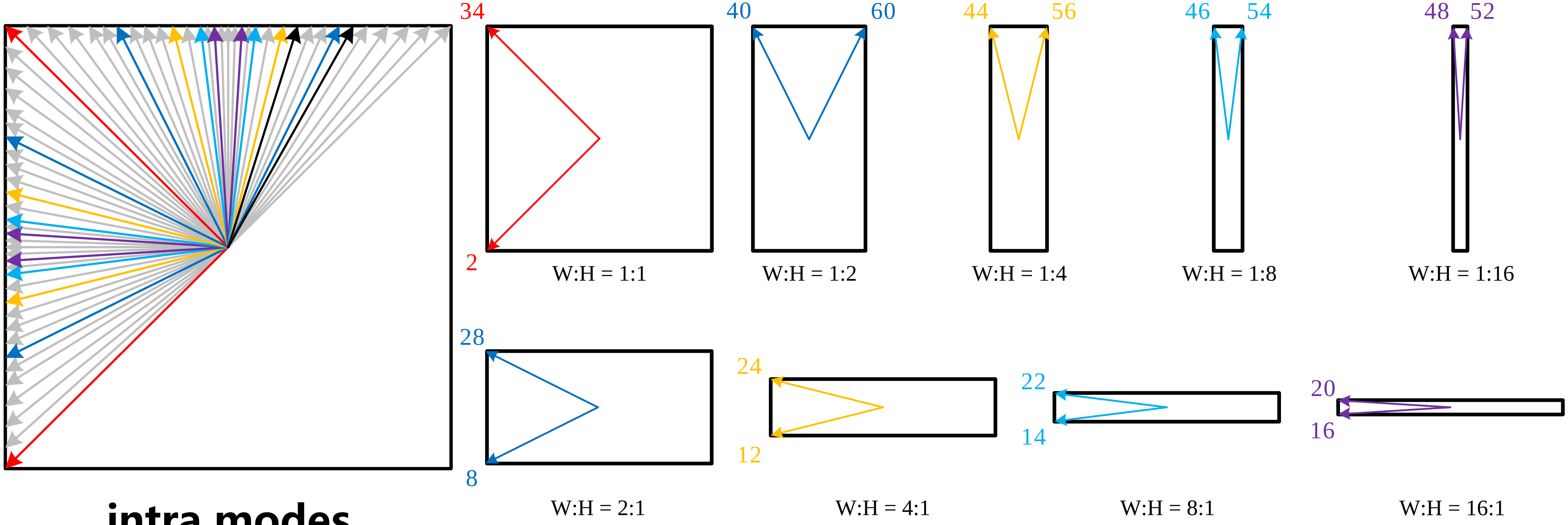
- Harmonized with TPM
  - Diagonal/anti-Diagonal direction for each block size is already exist in intra angle



intra modes

Experimental Results

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- GEO_64

RA over VTM6.0					
	Y	U	V	EncT	DecT
Class A1	-0.17%	-0.06%	-0.31%	103%	102%
Class A2	-0.23%	-0.21%	-0.23%	103%	102%
Class B	-0.21%	-0.18%	-0.34%	103%	104%
Class C	-0.72%	-0.94%	-1.15%	103%	105%
Class E					
Overall	**-0.34%**	**-0.37%**	**-0.53%**	**103%**	**103%**
Class D	-0.50%	-0.65%	-0.67%	103%	102%
Class F	-0.32%	-0.47%	-0.41%	101%	102%

LDB over VTM6.0					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.35%	-0.46%	-0.44%	104%	100%
Class C	-0.81%	-1.15%	-1.27%	104%	104%
Class E	-1.01%	-0.38%	-0.05%	103%	102%
Overall	**-0.67%**	**-0.67%**	**-0.62%**	**104%**	**102%**
Class D	-0.71%	-0.72%	-0.58%	105%	105%
Class F	-0.35%	0.03%	-0.01%	103%	102%

Thank Huawei for the cross-checking

- Test 1_56

RA over VTM6.0					
	Y	U	V	EncT	DecT
Class A1	-0.15%	-0.11%	-0.22%	102%	102%
Class A2	-0.18%	-0.31%	-0.19%	103%	102%
Class B	-0.22%	-0.16%	-0.26%	103%	102%
Class C	-0.65%	-0.89%	-0.90%	103%	104%
Class E					
Overall	**-0.31%**	**103%**	**-0.41%**	**103%**	**103%**
Class D	-0.48%	-0.73%	-0.64%	103%	101%
Class F	-0.30%	-0.42%	-0.37%	101%	102%

LDB over VTM6.0					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.37%	-0.38%	-0.58%	104%	102%
Class C	-0.76%	-0.93%	-0.75%	104%	104%
Class E	-0.91%	-0.49%	0.27%	102%	102%
Overall	**-0.64%**	**-0.59%**	**-0.42%**	**104%**	**103%**
Class D	-0.72%	-0.17%	-0.34%	105%	105%
Class F	-0.37%	-0.36%	0.30%	103%	105%

Experimental Results

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- Test 2_48

RA over VTM6.0					
	Y	U	V	EncT	DecT
Class A1	-0.13%	-0.06%	-0.30%	102%	102%
Class A2	-0.21%	-0.19%	-0.21%	103%	102%
Class B	-0.19%	-0.11%	-0.30%	103%	103%
Class C	-0.61%	-0.94%	-0.92%	103%	104%
Class E					
Overall	**-0.30%**	**-0.34%**	**-0.44%**	**103%**	**103%**
Class D	-0.46%	-0.74%	-0.50%	103%	101%
Class F	-0.28%	-0.41%	-0.32%	101%	102%

LDB over VTM6.0					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.37%	-0.36%	-0.36%	104%	102%
Class C	-0.78%	-0.94%	-0.78%	104%	105%
Class E	-0.78%	-0.39%	-0.35%	102%	103%
Overall	**-0.61%**	**-0.56%**	**-0.50%**	**103%**	**103%**
Class D	-0.68%	-0.79%	-0.53%	104%	106%
Class F	-0.43%	-0.54%	-0.32%	103%	104%

Thank Huawei for the cross-checking

- Test 3_40

RA over VTM6.0					
	Y	U	V	EncT	DecT
Class A1	-0.12%	-0.17%	-0.29%	102%	102%
Class A2	-0.15%	-0.17%	-0.19%	103%	102%
Class B	-0.20%	-0.11%	-0.26%	103%	103%
Class C	-0.59%	-0.77%	-0.87%	102%	105%
Class E					
Overall	**-0.28%**	**-0.31%**	**-0.42%**	**102%**	**103%**
Class D	-0.43%	-0.67%	-0.55%	103%	101%
Class F	-0.30%	-0.45%	-0.43%	101%	103%

LDB over VTM6.0					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.32%	-0.41%	-0.62%	104%	103%
Class C	-0.70%	-0.95%	-0.81%	104%	104%
Class E	-0.73%	0.03%	-0.12%	103%	102%
Overall	**-0.55%**	**-0.48%**	**-0.56%**	**103%**	**103%**
Class D	-0.57%	-0.76%	-0.54%	104%	105%
Class F	-0.37%	-0.47%	-0.31%	103%	105%

Conclusion

- JVET-P0250 use intra prediction to derive GEO weights
  - Remove redundant 4 tables from spec – intra already have similar table
  - Harmonized with intra mode and TPM
- Experimental results show gains compared to VTM6.0
  - **Test 1: 56 modes = 8 intra modes + 7 steps**
    - RA: -0.31% LD: -0.64%
  - **Test 2: 48 modes = 8 intra modes + 6 steps**
    - RA: -0.30% LD: -0.61%
  - **Test 3: 40 modes = 8 intra modes + 5 steps**
    - RA: -0.28% LD: -0.55%
- Based on the above results, it majority of the coding gain is kept after simplify weight calculation

More detail (TPM-example)

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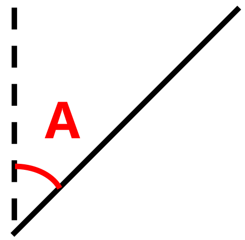
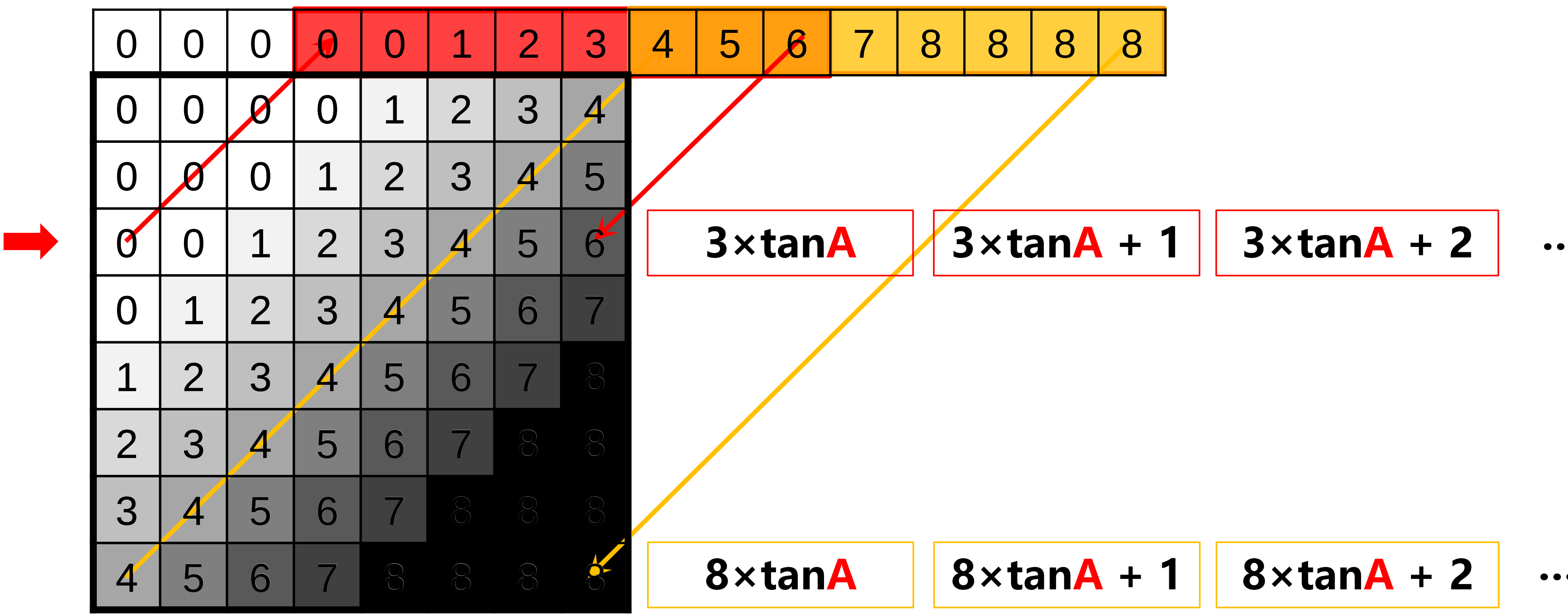
- TPM angle：





More detail (GEO-example)

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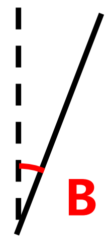
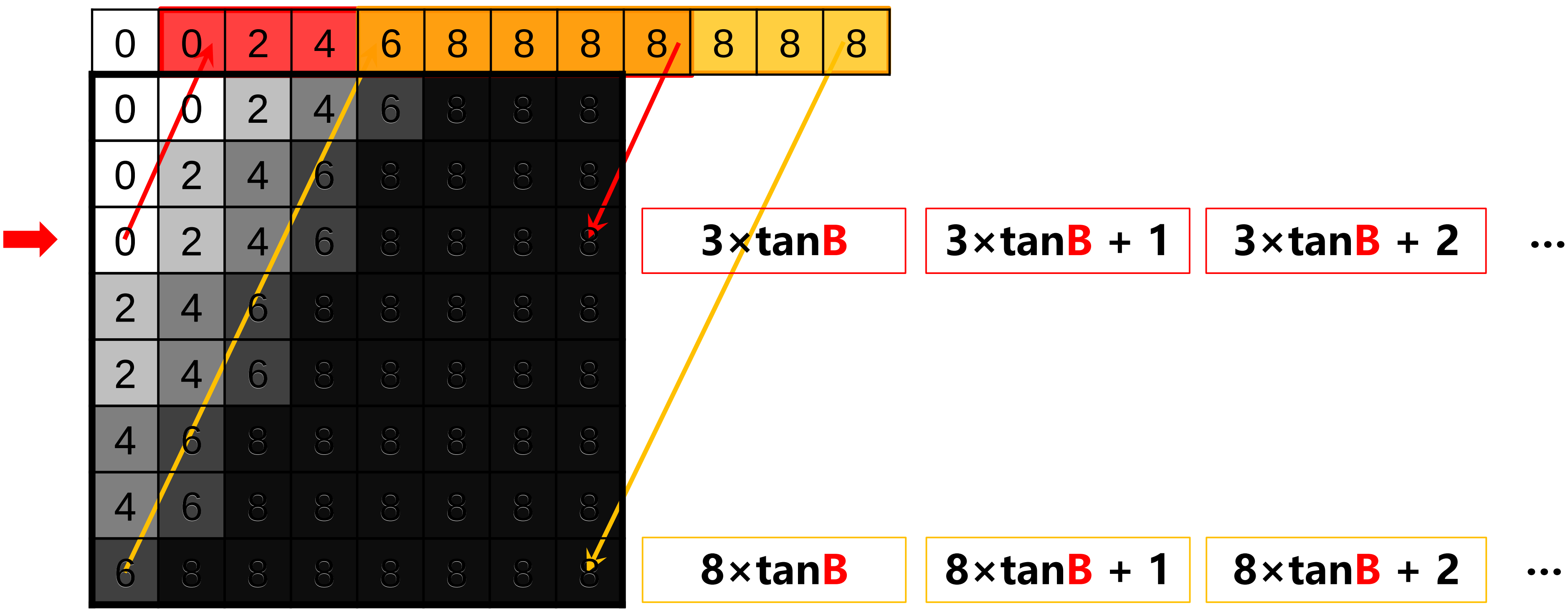
- GEO angle :





Conclusion

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- JVET-P0264
  - DistFromLine = $x * \cos\alpha - y * \sin\alpha - \mathbf{M} = \cos\alpha * (x - y * \tan\alpha) - \mathbf{M}$
  - When tan α is 1 : 2^N or 2^N : 1
    - DistFromLine = $\cos\alpha * (x - y \ll N) - \mathbf{M}$
- JVET-P0264 combined with JVET-P0107 slope based GEO
  - DistFromLine = $\cos\alpha * (x - y \ll N) - \mathbf{M}$ round cos α to 2^K

    $\approx 2^K * (x - y \ll N) - \mathbf{M}$ ***K changes according to angle***

    $= x \ll K - y \ll (N + K) - \mathbf{M}$
- JVET-P0264 combined with proposed
  - DistFromLine = $x - y \ll N - m$ ***No extra rounding and more straightforward***

Conclusion

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- Suggest to further study in CE based on JVET-P0264
- Benefits
  - Unify GEO and TPM weight calculation
    - ***Leaving TPM untouched***
  - More simpler calculation compared to JVET-P0107 + JVET-P0264
    - ***No extra rounding and more straightforward***
  - Maintaining coding gain in GEO modes
  - No extra table need to be added into the spec(reuse intra angular modes)
    - ***Intra already has diagonal/anti-diagonal direction for each block size***
- More things to be investigate
  - ***GEO parameter sets(angles and steps)***
  - ***Unify TPM and GEO***
    - ***Size restiction for GEO/TPM***
    - ***Angle unification for GEO/TPM***

THANKS！

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