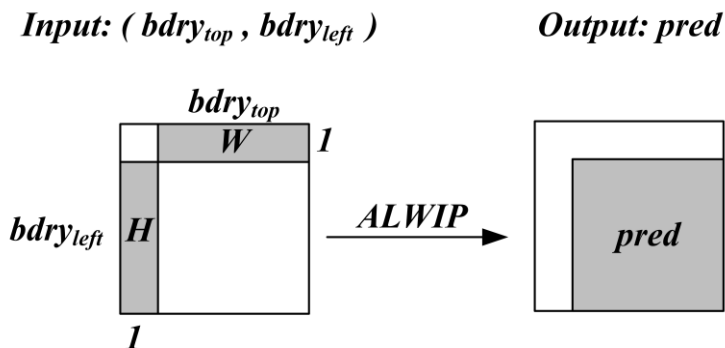

JVET-N0217

**Affine Linear Weighted
Intra Prediction**

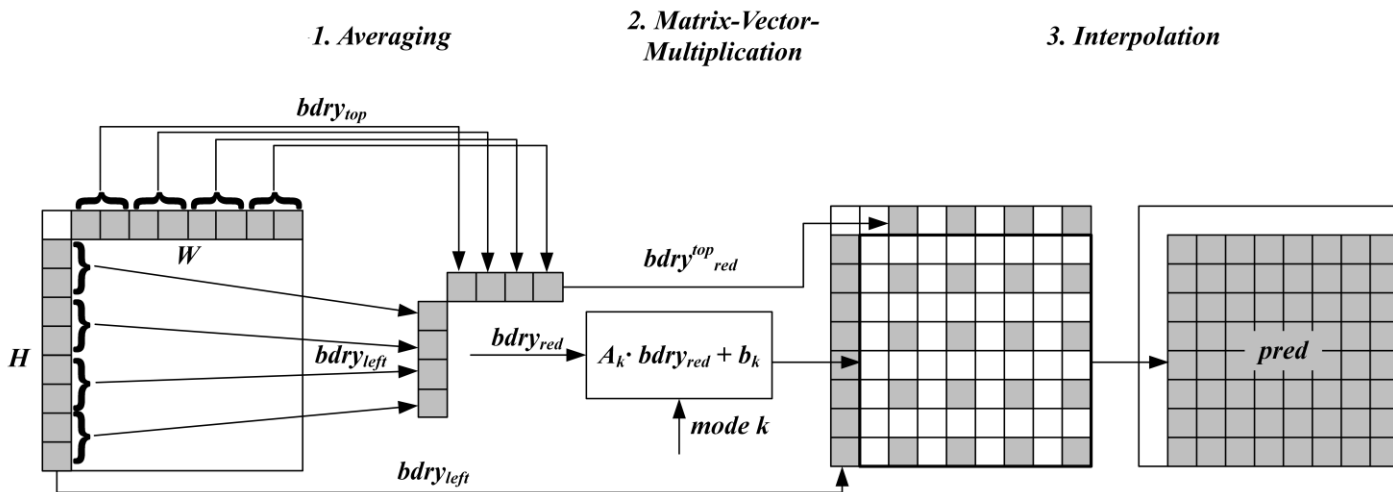
Overview

- For each luma $W \times H$ block, N intra prediction modes are proposed:
 - 35 modes for 4×4 blocks.
 - 19 modes for 8×4 , 4×8 and 8×8 blocks.
 - 11 modes, else.
- Input for the prediction are the W samples above and the H samples left of the block



Generation of the prediction signal

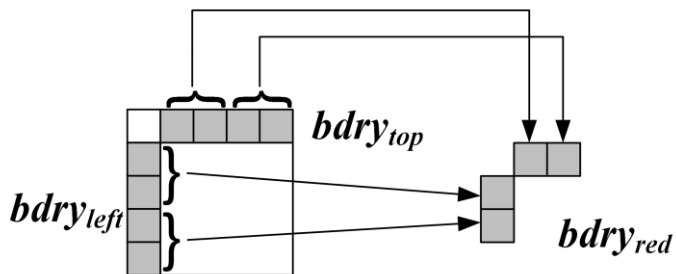
- The prediction is generated in 3 steps:
 - Averaging on the boundary.
 - Matrix vector multiplication and offset addition.
 - Bilinear interpolation of the result (not applied in 4x4 case).



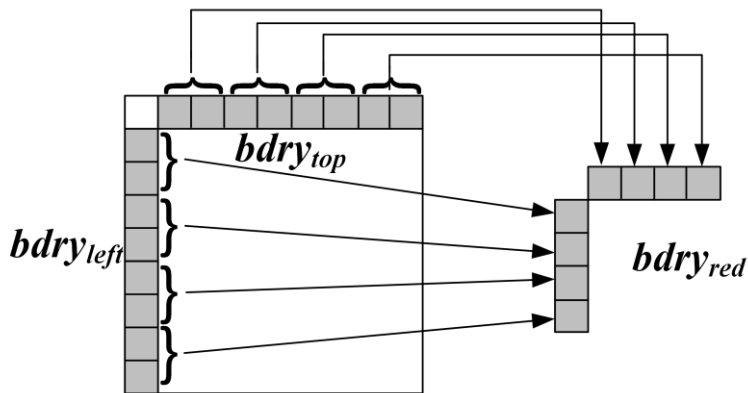
Averaging

- In 4x4 case, each boundary side is reduced to 2 samples.
- In all other cases, each boundary side is reduced to 4 samples

Averaging for 4x4:



Averaging in other cases:



Matrix vector multiplication

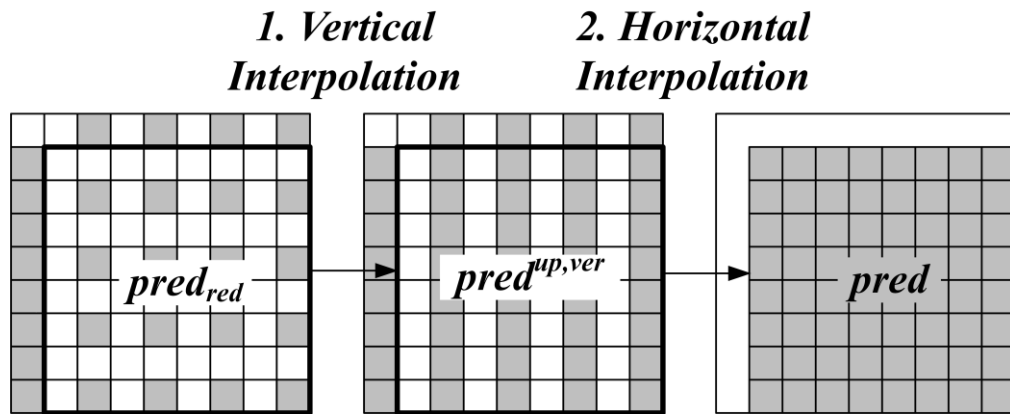
- Compute reduced prediction signal

$$pred_{red} = A \cdot bdry_{red} + b.$$

- Matrix A and offset vector b are fixed in advance, trained offline.
- Three sets S_0, S_1, S_2 of matrices and offset vectors are used:
 - S_0 : 18 matrices of size 16x4; 18 offset vectors of size 16.
Used for 4x4 blocks.
 - S_1 : 10 matrices of size 16x8; 10 offset vectors of size 16.
Used for 4x8, 8x4 and 8x8 blocks.
 - S_2 : 6 matrices of size 64x8; 10 offset vectors of size 64.
Used for all other blocks.
- Input and output for the matrix vector multiplication can be transposed, thus resulting in 35 (resp. 19, 11) modes.

Bilinear Interpolation

- Given $pred_{red}$ the interpolation consists of two steps:
 - If $W \geq H$, first apply vertical 1D interpolation to get $pred^{up,ver}$
 - Then apply horizontal 1D interpolation to get the final $pred$.
 - If $W < H$, reverse the order of the interpolation steps.
 - Interpolation only needs one bit shift/one addition p. sample (interpolated sample is average of two neighboring samples).



Complexity assessment

- Total memory of all matrices and offset vectors used is less than 8 kilobyte (as required by hardware experts).
- Total number of multiplications per sample needed to generate prediction signal is not greater than 4.
- This even holds if bilinear interpolation is counted as 2 multiplications per sample to be interpolated.
- Thus: Number of multiplications needed to generate prediction signal is **not higher** than in the case of conventional intra prediction.

Encoder speed-ups

- Initialize short-list of possible candidates for Full-RD search using l_1 -norm in Hadamard domain.
- If k modes of short-list have been tested with full RD search, make a decision, based on the RD-costs of these k modes, whether mode $k+1$ is to be tested or not.
- Analogous to speed-ups used in other parts of the current reference software (intra- and inter-prediction/transforms...).

Mode signaling

- MPM list with 3 MPMs.
- For the MPM list generation, PU_above and PU_left are considered:
 - If PU_above uses same type of ALWIP-prediction, its intra mode is inserted into MPM list.
 - If PU_above uses conventional intra-prediction, the conventional mode is mapped to an ALWIP mode via fixed table.
 - Else, PU_above is not used.
- PU_left is used analogously.
- Remaining entries in the MPM-list are filled via a fixed default list.

Adaption of conventional MPM list generation

- If on a given PU an MPM list for the conventional intra prediction mode is to be generated, and if PU_above uses ALWIP with mode $mode_{ALWIP}$, the following is done:
 - The above PU is treated as if it were using conventional intra prediction with mode $mode_{conventional}$.
 - Here, $mode_{conventional}$ is derived from $mode_{ALWIP}$ via a fixed lookup table.
- PU_left analogously.
- Above method applies to any kind of MPM list generation used for the conventional intra prediction modes.

Experimental results

- CE 3-4.1:

AI	Y	U	V	Enc Time	Dec Time
	-0.79	-0.27 %	-0.28 %	138 %	99 %

RA	Y	U	V	Enc Time	Dec Time
	-0.42 %	-0.64 %	-0.64 %	104 %	99 %

- CE 3-4.1 with speed-up:

AI	Y	U	V	Enc Time	Dec Time
	-0.50 %	-0.21 %	-0.23 %	110 %	100 %

Conclusion

- Affine linear weighted intra prediction provides intra prediction modes that are not more complex than conventional intra prediction modes but still give coding gain.
- Random access: -0.42% gain with 104% enc-time, 99% dec time.
- An adoption would open the possibility for further improvements and harmonizations carried out by a larger group.
- Recommendation: Adopt into next version of the VVC-standard draft.