JCTVC-A123 Video Coding Technology Proposal by NCTU

Parametric Overlapped Block Motion Compensation (POBMC)

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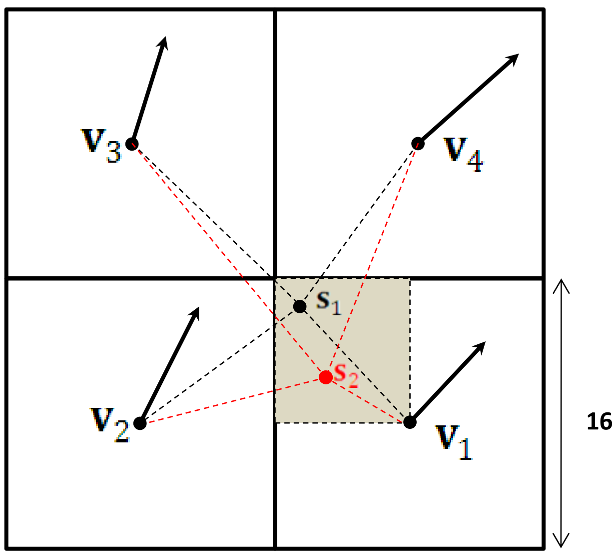
Summary

- Block-based Hybrid Codec based on KTA 2.4r1
  - Incorporate POBMC, TMP-Skip
  - Enable EAIF, RDOQ, QALF, EMB, MDDT
- Compression Performance
  - 22.04% saving, 0.90dB gain over Alpha
  - 21.93% saving, 0.91dB gain over Beta
  - 41.46% saving, 1.98dB gain over Gamma
- Highlighted Aspects
  - Alleviate blocking artifacts, enhance error resilience

Overlapped Block Motion Comp.

- Prediction based on MVs of neighboring blocks

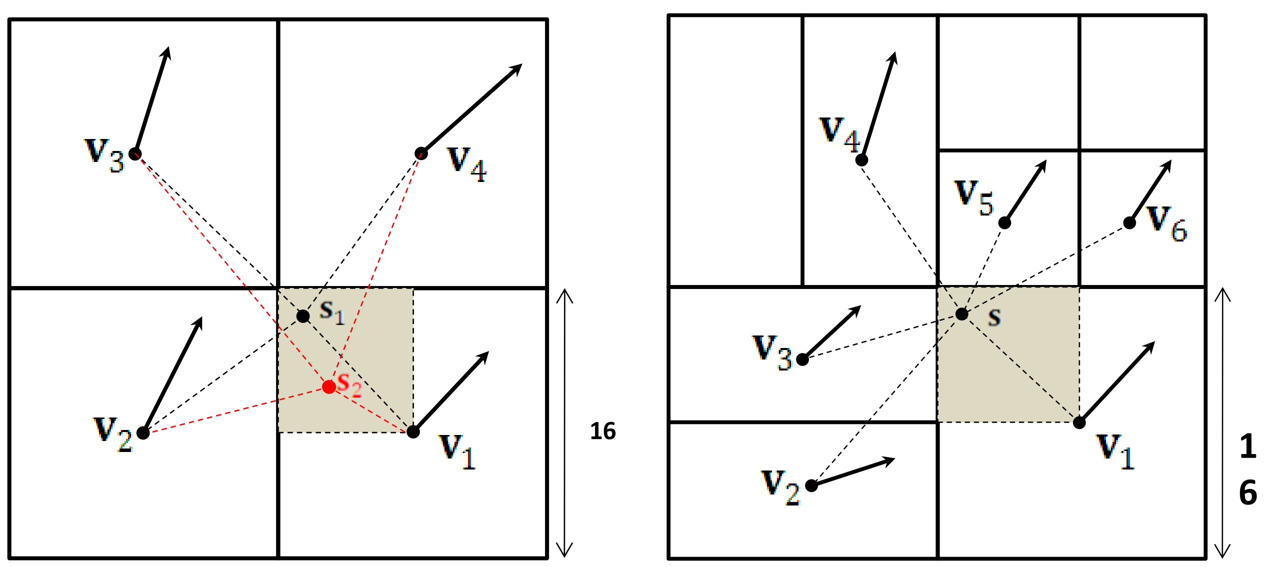


$$I_k(\mathbf{s}_1) - \underbrace{\sum_{i=1}^{4} w_i I_{k-1}(\mathbf{s}_1 + \mathbf{v}_i)}_{\text{LMMSE Estimate}}$$

- Weight vector varies with relative pixel position

Problem

- Weight vector depends on absolute pixel pos.
  → Different pixels, different weight vectors
- How to obtain? How to keep?



Parametric Solution

- To give a closed-form formula for weight vector

$$\mathbf{w}^* = \arg\min_{\mathbf{w}} E\left\{\left(I_k(\mathbf{s}) - \sum_{i=1}^{L} w_i I_{k-1}(\mathbf{s} + \mathbf{v}(\mathbf{s}_i))\right)^2\right\} \quad \text{s.t.} \quad \sum_{i=1}^{L} w_i = 1$$

- Signal Model & Assumption
  - ① Block MV approximates motion at block center
  - ② Motion difference follows normal distribution

$$v_x(\mathbf{s}_1) - v_x(\mathbf{s}_2), v_y(\mathbf{s}_1) - v_y(\mathbf{s}_2) \sim N(0, \alpha r^2(\mathbf{s}_1, \mathbf{s}_2))$$

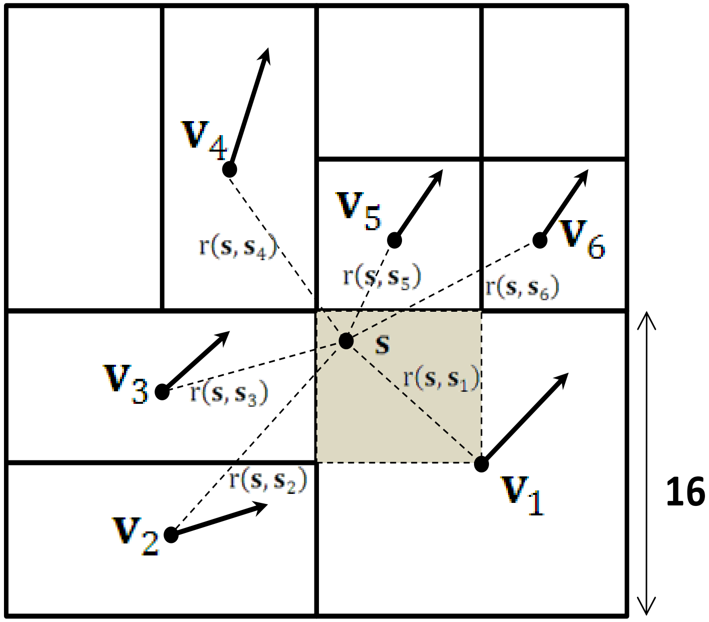
Parametric Solution

- Under mild conditions

$$w_i^* = \frac{\frac{1}{r^2(\mathbf{s}, \mathbf{s}_i)}}{\sum_{i=1}^{L} \frac{1}{r^2(\mathbf{s}, \mathbf{s}_i)}}, 1 \leq i \leq L$$

- Interpretation

  The optimal weight associated with a block MV is inversely proportional to the squared distance from its block center to the predicted pixel



Extension to Bi-Prediction

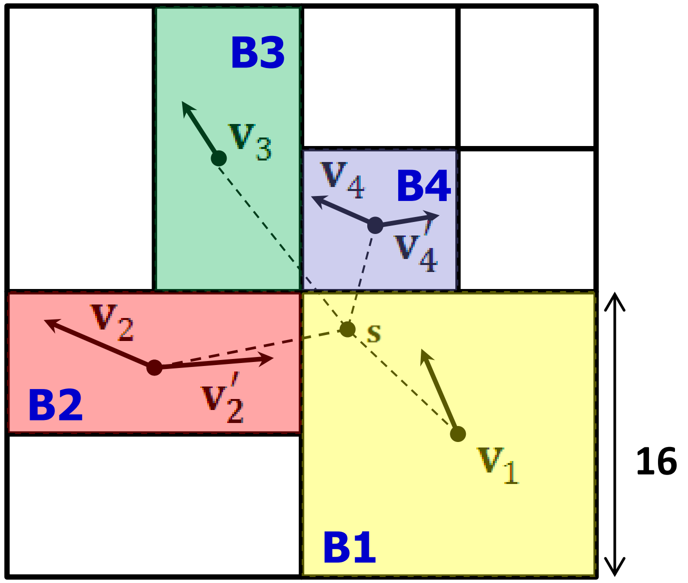
- Generate predictors using prediction modes of neighboring partitions

$$p_1(\mathbf{s}) = I_{k-2}(\mathbf{s} + \mathbf{v}_1)$$

$$p_2(\mathbf{s}) = \frac{1}{2} I_{k-2}(\mathbf{s} + \mathbf{v}_2) + \frac{1}{2} I_{k+3}(\mathbf{s} + \mathbf{v}_2{}')$$

$$p_3(\mathbf{s}) = I_{k-1}(\mathbf{s} + \mathbf{v}_3)$$

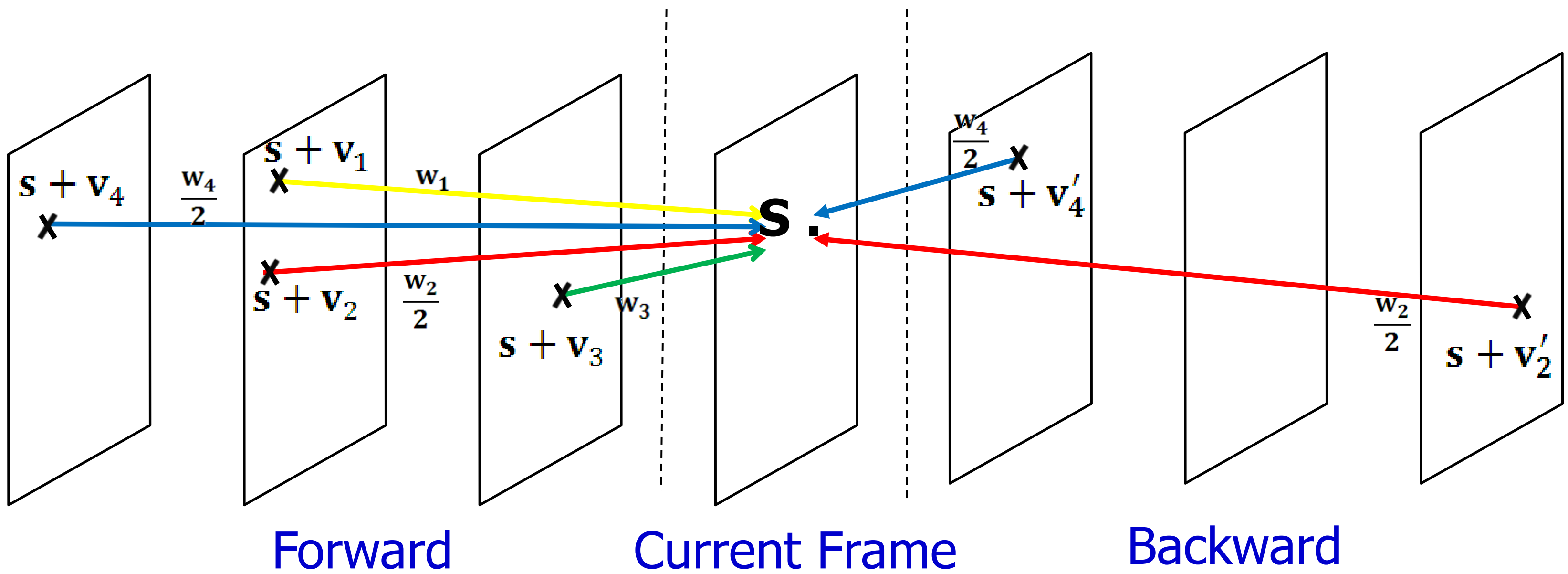
$$p_4(\mathbf{s}) = \frac{1}{2} I_{k-3}(\mathbf{s} + \mathbf{v}_4) + \frac{1}{2} I_{k+1}(\mathbf{s} + \mathbf{v}_4{}')$$



Extension to Bi-Prediction

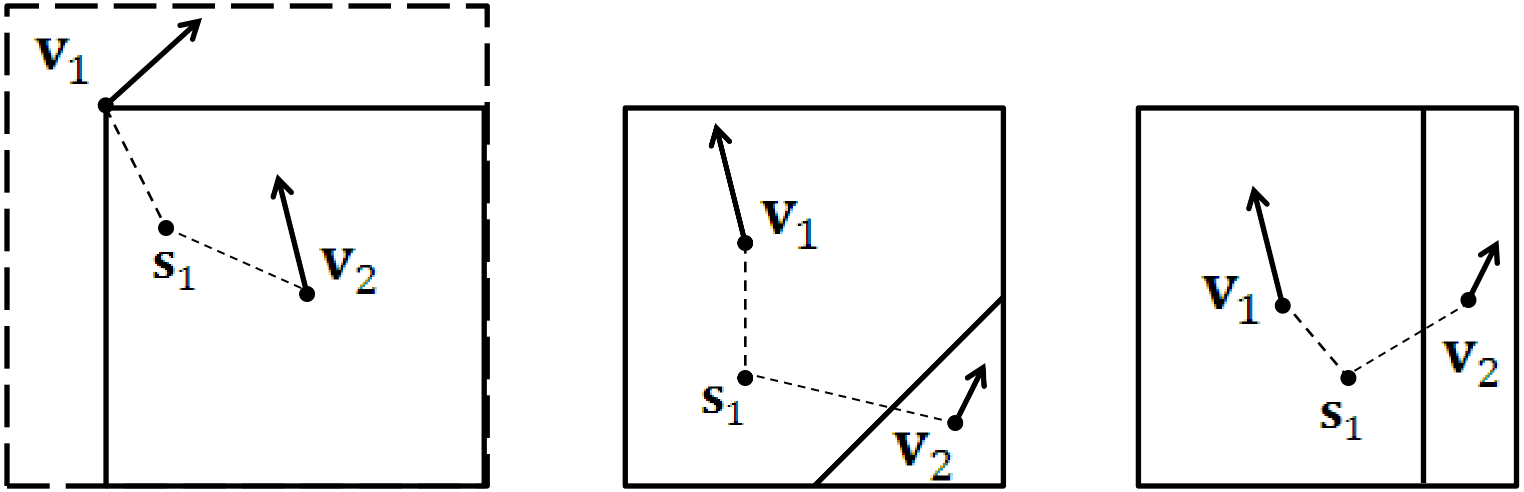
- Combine resulting predictors using POBMC

$$w_1 p_1(\mathbf{s}) + w_2 p_2(\mathbf{s}) + w_3 p_3(\mathbf{s}) + w_4 p_4(\mathbf{s})$$



Application to Various Partitions

- Block MV as motion at block centroid



TMP Geometry Assymmetric

Compression Performance

Constrain1	Y BD-rate(%)	Y BD-SNR(dB)
Class A	**19**	**0.86**
Class B	**25**	**0.78**
Class C	**23**	**1.08**
Class D	**19**	**0.87**
Overall	**22**	**0.89**

Constrain2	Vs. Beta		Vs. Gamma	
	Y BD-rate(%)	Y BD-SNR(dB)	Y BD-rate(%)	Y BD-SNR(dB)
Class B	**28**	**0.96**	**46**	**1.95**
Class C	**18**	**0.82**	**37**	**1.82**
Class D	**11**	**0.52**	**34**	**1.67**
Class E	**32**	**1.46**	**49**	**2.64**
Overall	**22**	**0.91**	**41**	**1.98**

Complexity Characteristics

- Multi-hypothesis Motion Compensation
  - Incur moderate increase in memory access (~6 hypotheses used on average)
  - Require to buffer motion information
- Spatially Varying OBMC Filter
  - Increase computational complexity (# of filter taps ~6)

Complexity Analysis

Decoding Time Ratio	Decoding w/ Output		Decoding w/o Output	
	Constraint set 1	Constraint set 2	Constraint set 1	Constraint set 2
Class A	59.9	N/A	120.4	N/A
Class B	36.6	68.2	64.0	121.3
Class C	46.2	66.7	87.9	145.5
Class D	91.2	142.0	94.1	144.2
Class E	N/A	24.8	N/A	107.3
Avg.	**58.5**	**75.4**	**86.2**	**128.2**

Decoding Time Ratio w/Output	V1 (CfP)	V2
Class A S01 R5 C1	93	39
Class B S03 R5 C2	98	41
Class B S05 R5 C1	47	20
Class C S09 R5 C1	53	27
Class D S14 R5 C2	123	28
Class E S18 R5 C2	138	46

Conclusion

- POBMC offers a reconstruction framework allowing MVs associated with any motion partitions to be utilized for OBMC
- It opens up new design possibilities for more efficient motion sampling and partition
- Preliminary results show that it has a comparable gain to EAIF and, when combined with EAIF, shows little loss in coding gain
- Many issues are yet to be further investigated

Q & A