

Context Adaptive Lagrange Multiplier (CALM) for Motion Estimation in JM -- Improvement

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Introduction

- ◆ H.264/AVC JM uses R-D Lagrange cost function for motion estimation to find the optimal motion vector for a given QP

$$J(\vec{v}, qp) = D(\vec{v}, qp) + \lambda_{MV} R_{MV}(\vec{v}) \quad (1)$$

where

$$\lambda_{MV} = 0.92 \cdot 2^{(QP-12)/6} \quad (2)$$

Motivation of the Proposal

- ◆ **Observation**: Fast ME can have better R-D performance than Full search (JVT-P021)
- ◆ Many sequences, especially medium and high motions
- ◆ **Problem**: the Lagrange cost for ME has limitations

Context Adaptive Lagrange Multiplier (CALM) method

- ◆ We proposed Context Adaptive Lagrange Multiplier (CALM) method in JVT Geneva meeting
- ◆ Lagrange multiplier becomes adaptive to the context (neighboring MBs or upper layers of the same MB)
- ◆ Cost function (1) is adjusted according to the estimated distortion
- ◆ New cost function:

$$J(\vec{v}, qp) = D(\vec{v}, qp) + \lambda_{MV} F_{CALM} R_{MV}(\vec{v}) \quad (3)$$

Context Adaptive Lagrange Multiplier (CALM) method (cont.)

The F_{CALM} is obtained by pseudo-code:
FOR 16x16 macroblocks:

IF both left and above neighbors available {

$$J_{curr}(\vec{v}, qp) = [J_{left}(\vec{v}, qp) + J_{above}(\vec{v}, qp)] / 2$$

} ELSEIF left neighbor available {

$$J_{curr}(\vec{v}, qp) = J_{left}(\vec{v}, qp)$$

} ELSEIF above neighbor available {

$$J_{curr}(\vec{v}, qp) = J_{above}(\vec{v}, qp)$$

} ELSE {

$$J_{curr}(\vec{v}, qp) = J_{default}(\vec{v}, qp)$$

}

Context Adaptive Lagrange Multiplier (CALM) method (cont.)

FOR 16x8, 8x16, 8x8, 8x4, 4x8, and 4x4 blocks:

$$J_{curr}(\vec{v}, qp) = J_{upper-layer}(\vec{v}, qp)$$

IF $J_{curr}(\vec{v}, qp) < J_{default}(\vec{v}, qp)$ {

// the cost is not big enough, don't scale

$$F_{CALM} = 1.0$$

} ELSE {

$$F_{CALM} = \sqrt{\frac{J_{curr}(\vec{v}, qp)}{J_{default}(\vec{v}, qp) \times \kappa(qp)}}$$

}

where

$$K(qp) = \log_2(\lambda_{mv}(\max(qp - 6, 0)) + 1.0)$$

Issues with the last proposal

- ◆ There was a lack of experimental data for low bit rates.
- ◆ R-D performance for non-fixed QP (rate control enabled) was not tested. What if the neighboring blocks had different QP's?
- ◆ Why was it that the proposed method could achieve better rate-distortion performances?

Experiments and Analysis of CALM

- ◆ This method has comparable improvements for low bit rates with the corresponding PSNR in the range of 30dB – 39dB
- ◆ This method works for rate control
- ◆ The main reason this method improves the R-D performance is it better captures the ‘true’ motions

More Analysis

- ◆ Our method BD PSNR gains for U and V components of 0.164 dB and 0.166 dB when RDO is off
- ◆ Our improvements are close to JM with RDO on (0.177dB and 0.181dB for U and V components)
- ◆ For coastguard.qcif, the reference software has worse rate-distortion performance for both U and V components when RDO is turned on than both methods when RDO is turned off.

Configuration for Experiments

Name	Value
ProfileIDC	66/77
LevelIDC	41
UseHadamard	ON
SearchRange	32 - 64
NumberReferenceFrames	1
SymbolMode	CAVLC/CABAC
RCEnable	0/1
RDOptimization	0/1

ContextAdaptiveLagrangeMultiplier

0/1

Experimental Result Summary

Reference vs. Proposed (RDO off)

sequences	frame rate	number of frames	Y BD Bit Rate Change	BD Y-PSNR change	U BD Bit Rate Change	BD U-PSNR change	V BD Bit Rate Change	BD V-PSNR change
foreman	30	100	-2.42%	0.122	-5.31%	0.134	-4.47%	0.171
news	30	100	-2.55%	0.167	-3.88%	0.176	-3.75%	0.151
silent	30	100	-2.50%	0.139	-3.56%	0.149	-3.58%	0.131
coastguard	30	100	-1.51%	0.066	-4.31%	0.083	0.36%	0.014
table	30	100	-1.67%	0.087	-3.06%	0.103	-3.56%	0.145
foreman_cif	30	100	-1.61%	0.07	-2.90%	0.071	-2.97%	0.09
harbor_cif	30	100	-2.65%	0.125	-4.27%	0.085	-4.49%	0.078
crew_cif	30	100	-1.26%	0.057	-1.06%	0.041	-2.08%	0.079
stefan_cif	30	100	-3.70%	0.189	-5.36%	0.173	-5.90%	0.193
bus_cif	30	100	-3.05%	0.165	-4.34%	0.121	-5.87%	0.166
football_cif	30	100	-4.21%	0.263	-6.24%	0.255	-6.43%	0.212
cheerleader_D1	30	10	-4.93%	0.361	-9.13%	0.576	-9.47%	0.567
Average			-2.67%	0.151	-4.45%	0.164	-4.35%	0.166

Experimental Result Summary

Reference (RDO off) vs. Reference (RDO on)

sequences	frame rate	number of frames	Y BD Bit Rate Change	BD Y-PSNR change	U BD Bit Rate Change	BD U-PSNR change	V BD Bit Rate Change	BD V-PSNR change
foreman	30	100	-5.67%	0.291	-5.72%	0.15	-5.01%	0.177
news	30	100	-6.43%	0.43	-5.77%	0.273	-5.10%	0.215
silent	30	100	-6.17%	0.361	-4.32%	0.162	-5.30%	0.172
coastguard	30	100	-5.23%	0.226	13.49%	-0.174	8.67%	-0.332
table	30	100	-7.15%	0.382	-2.36%	0.09	-4.59%	0.18
foreman_cif	30	100	-6.37%	0.282	-0.71%	0.007	-2.94%	0.081
harbor_cif	30	100	-4.41%	0.212	0.99%	-0.018	3.31%	-0.054
crew_cif	30	100	-7.16%	0.335	-5.94%	0.18	-6.42%	0.237
stefan_cif	30	100	-7.51%	0.389	-4.60%	0.146	-4.02%	0.138
bus_cif	30	100	-6.16%	0.337	-5.01%	0.135	-5.91%	0.174
football_cif	30	100	-6.87%	0.432	-6.97%	0.284	-8.47%	0.276
cheerleader_D1	30	10	-9.65%	0.699	-13.80%	0.886	-14.4%	0.903
Average			-6.57%	0.365	-3.39%	0.177	-4.18%	0.181

Experimental Result Summary

Reference vs. Proposed
(RDO off, Rate Control Enabled)

sequences	frame rate	number of frames	Y BD Bit Rate Change	BD Y-PSNR change	U BD Bit Rate Change	BD U-PSNR change	V BD Bit Rate Change	BD V-PSNR change
foreman	30	100	-1.39%	0.068	-2.98%	0.078	-4.26%	0.128
news	30	100	-1.64%	0.108	-2.58%	0.104	-2.41%	0.079
silent	30	100	-1.12%	0.065	-1.97%	0.064	-3.02%	0.093
coastguard	30	100	-1.81%	0.079	-2.93%	0.038	-1.45%	0.027
table	30	100	-1.00%	0.058	-0.44%	0.017	-2.94%	0.121
foreman_cif	30	100	-1.09%	0.045	-3.79%	0.081	-4.19%	0.126
harbor_cif	30	100	-2.66%	0.129	-4.55%	0.099	-5.47%	0.118
crew_cif	30	100	-0.81%	0.037	-1.79%	0.054	-2.03%	0.072
stefan_cif	30	100	-3.13%	0.157	-4.44%	0.131	-4.78%	0.149
bus_cif	30	100	-2.82%	0.149	-4.63%	0.095	-5.43%	0.145
football_cif	30	100	-3.95%	0.229	-6.05%	0.213	-6.33%	0.183
cheerleader_D1	30	10	-4.56%	0.323	-8.15%	0.459	-8.18%	0.446
Average			-2.17%	0.121	-3.69%	0.119	-4.21%	0.141

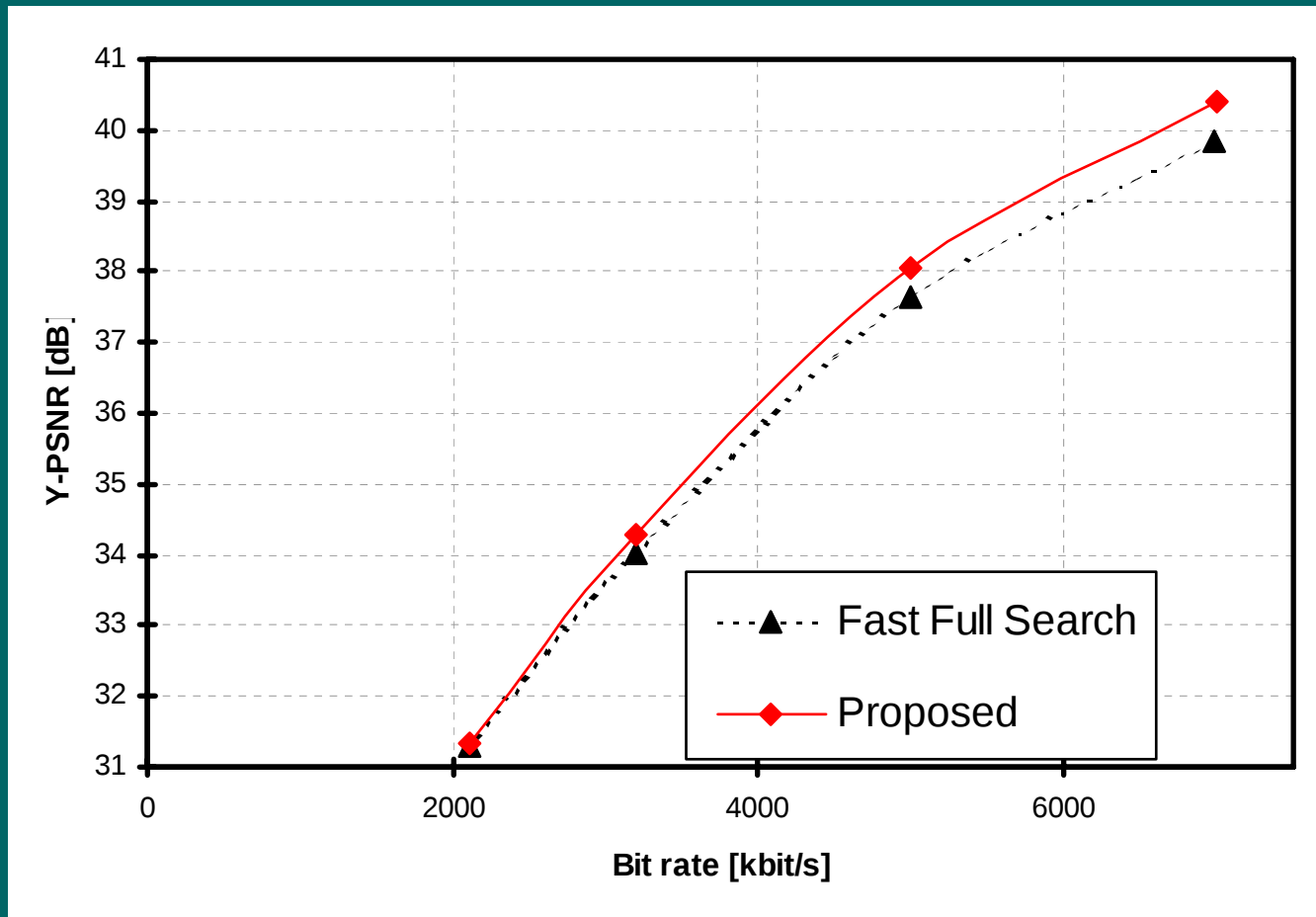
Motion Vectors (reference software)



Motion Vectors (proposed)

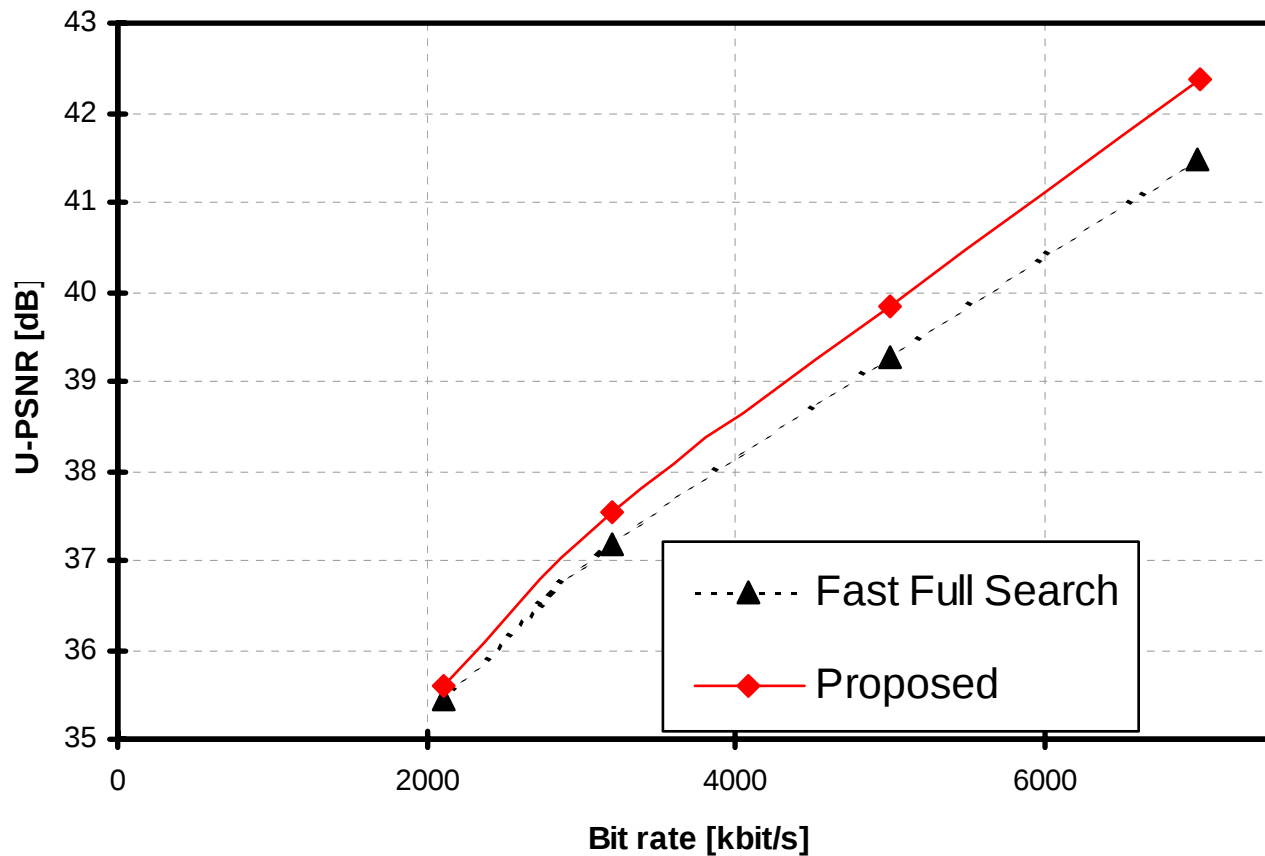


R-D Curves for Cheerleader D1 (Y-Component)

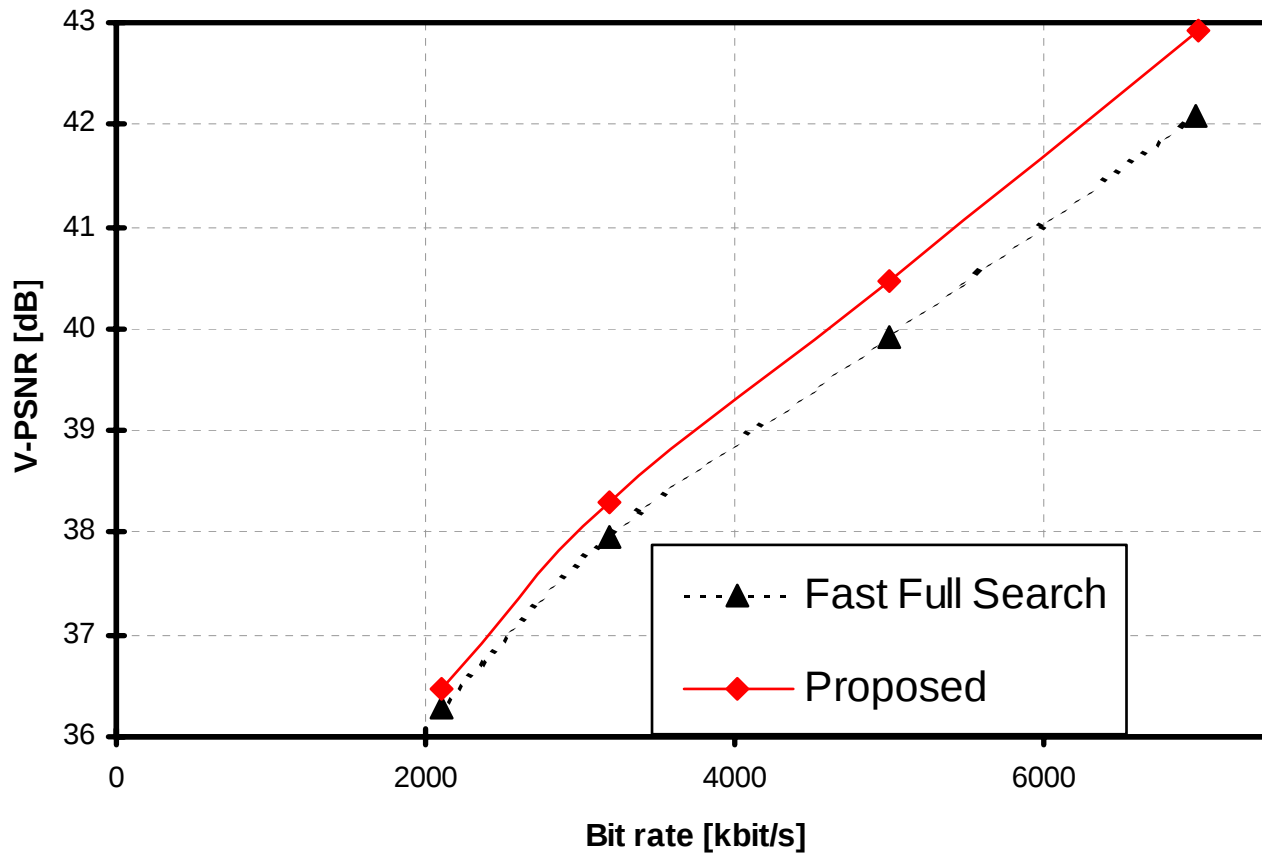


720x480, 30fps, CAVLC, IPPP, RDO=OFF

R-D Curves for Cheerleader D1 (U-Component)



R-D Curves for Cheerleader D1 (V-Component)



Conclusion

- ◆ The CALM method achieves better rate-distortion performance with negligible extra computational cost
- ◆ This method can be applied to different bit rates
- ◆ This method can be used for rate control
- ◆ The code change associated with this method is about 30-50 lines

Acknowledgement

- ◆ Special thanks to Jianhua Zheng of Huawei Technologies CO. Ltd for verifying the experimental results.