Joint Video Team (JVT) of ISO/IEC MPEG & ITU-T VCEG
(ISO/IEC JTC1/SC29/WG11 and ITU-T SG16 Q.6)
17th Meeting: Nice, FR, 14-21 October, 2005

Document: JVT-Q040
Filename: JVT-Q040.doc

Title: **CE8: Variable length codes for SVC**

Status: Input Document to JVT

Purpose: Proposal / Report

Author(s) or Contact(s): Justin Ridge / Marta Karczewicz
6000 Connection Dr., MS 3-4-1400
Irving, TX 75039
USA
Tel: +1 972 374 0628
Email: Justin.Ridge@nokia.com

Source: Nokia

Abstract

At the previous JVT meeting, software enabling entropy coding using VLCs in progressive refinement (FGS) layers was presented. A core experiment was created to enable further consideration of that feature prior to acceptance into the JSVM. This contribution reviews the VLC for FGS feature, notes some minor improvements made during the course of the CE, and presents results indicating that the overhead associated with VLC for FGS is in line with the single-layer case.

Introduction

Non-scalable H.264/AVC provides a choice of two entropy coders, CABAC and CAVLC. It is generally accepted that CABAC offers superior coding efficiency at the price of complexity. CAVLC is particularly appealing for use in complexity-constrained devices, such as mobile terminals.

If the scalable extension to H.264/AVC is to be useful in a broad range of scenarios, it should be capable performing adequately on complexity-constrained devices. To this end, we believe that CAVLC is necessary, at least for the base layer and quality enhancements.

This need was recognized at the previous JVT meeting, where it was agreed to add support for CAVLC in the base layer, and add the VLC for quality enhancements to the software.

Action since last meeting

Source code for the CAVLC features was included with contribution JVT-P056, and was therefore available prior to the previous JVT meeting.

However, due to unexpected delays in the JSVM software implementation process, CAVLC has not yet been added to the CVS server. We anticipate this will happen within a couple of weeks after the current meeting.

In lieu of CVS availability, the VLC feature was ported to JSVM 2.1.4 and shared with other CE participants in advance of the current meeting. Source code is also included with this contribution.

Review of VLC for FGS

Significance pass

In the significance pass, rather than coding each coefficient individually, a single VLC symbol is emitted for each cycle in cyclical block coding, specifying the number of coefficients processed.

The VLCs used in the significance pass are modified start-step-stop codes, as previously described in JVT-C086 and VCEG-L19. These codes are characterized by a cutoff parameter, 'm'. Symbols less than or equal to 'm' are encoded using an exponential Golomb (expGolomb) code. A symbol 'C' with value greater than 'm' is encoded in two parts: a prefix of ones, length

$$p = \left\lfloor \frac{C-m}{3} \right\rfloor + m$$

and a "remainder" suffix of either 00, 01, or 10. The codewords corresponding to m=2 and m=4 are shown in Table 1.

Symbol	m=1	m=5
0	1: 0	1: 0
1	3: 100	2: 10
2	3: 101	3: 110
3	3: 110	4: 1110
4	5: 11100	5: 11110
5	5: 11101	7: 1111100
6	5: 11110	7: 1111101
7	7: 1111100	7: 1111110

Table 1: VLCs for m=1, m=5

For the significance pass, the optimal value of 'm' depends on both the starting position of the cycle, and the position of the last-coded coefficient in the base layer. The optimal value of 'm' varies significantly not only between sequences but also between frames within a given sequence. Consequently, a context table mapping cycle start position and last-coded base position to 'm' is coded once per FGS slice.

Because the base layer must be processed before encoding the enhancement layer, analyzing the base layer to determine the optimal mapping need not add to encoder complexity. To minimize the overhead associated with the mapping table, monotonicity is enforced in each dimension of the already-sparse table. Thus we need only record the starting value and step points for a reasonably small number of values. The coding process for the table is the same as for EOB offsets (below).

In the significance pass, coding the value zero (i.e. no coefficients processed) indicates an end-of-block (EOB).

However, the probability of an EOB is greatly influenced by cycle start position, and depending on the cycle start position it may not be the most probable symbol. To maintain a structured start-step-stop code, a vector specifying the EOB offsets to be used for each cycle start position is encoded once per frame. This vector is constrained to be monotonically decreasing as cycle number increases. For example, the vector {4 2 1 1 0 0 …} means that the EOB should be symbol 4 in cycle 0, symbol 2 in cycle 1, symbol 1 in cycles 2 & 3, and symbol 0 (most probable symbol) in subsequent cycles. The first value (4) is encoded using a Golomb code with k=2, followed by the number of times each offset appears in the vector. For example, 4 appears no more times after the first value, so 0 is encoded; 3 does not appear at all, so 0 is encoded; 2 appears once so 1 is coded; 1 appears twice so 2 is coded. Thus the symbols coded are {0,0,1,2}. Performing this coding once per frame incurs minimal overhead.

An EOB symbol indicates that no block coefficients coded in the significance pass had a magnitude greater than one. This is true in the great majority of cases.

In the event that coefficients coded in the significance pass have a magnitude greater than one, the number of such coefficients (x) and the maximum magnitude (y) are combined using the formula 16x+y to give an offset value. The EOB symbol coded is the number of coefficients remaining plus the offset. At the decoder, such an "overshoot condition" is easily detected. Refinement bits then indicate the exact magnitude of each significant coefficient.

Refinement pass

In the refinement pass, all refinement bits for a given 4x4 or 8x8 block are grouped and coded together. A fixed VLC was proposed in JVT-P056; further work in the core experiment indicated that an adaptive VLC yields a reduction in bit rate. Accordingly, a second VLC has been added, and is selected in cases where the probability of zero (as measured through observing previously-decoded refinement bits in the slice) is less than 7/8. Individual flags are used if the probability of zero is less than 2/3.

Coded block pattern (CBP)

The concept of using a "coded block pattern" (CBP) is borrowed from regular H.264/AVC. We omit the bits from blocks already coded in the base layer, and use a context based on the base-layer CBP value, but otherwise the mechanism is unchanged.

Coded block flag (CBF)

In JVT-P056, independent flags were used to indicate whether or not a 4x4 block is coded. There is a clear benefit to grouping coded block flags, utilizing the same principle as the CBP. Consequently, we propose collecting all CBFs for a given 8x8 sub-MB together. This modification would also affect the CABAC process, although it should make no difference whatsoever to CABAC efficiency.

Results

See accompanying Excel workbook.

We note that the entropy coding method can be configured independently for each layer. Therefore, although CAVLC performs worse on higher spatial resolutions (as expected), this we would advocate simply turning it off in such layers rather than disregarding the feature entirely.

Conclusion

This document has largely served as a review of JVT-P056, which was presented along with source code at the previous JVT meeting. We remain of the opinion that CAVLC is a useful feature for FGS, and that the performance overhead is in line with single-layer expectations. Therefore, we propose its incorporation into the JSVM.

(Append for Proposal Documents)

JVT Patent Disclosure Form

International Telecommunication Union
Telecommunication Standardization Sector

International Organization for Standardization

International Electrotechnical Commission

Joint Video Coding Experts Group - *Patent Disclosure Form*

(Typically one per contribution and one per Standard | Recommendation)

Please send to:

JVT Rapporteur Gary Sullivan, Microsoft Corp., One Microsoft Way, Bldg. 9, Redmond WA 98052-6399, USA
Email (preferred): Gary.Sullivan@itu.int Fax: +1 425 706 7329 (+1 425 70MSFAX)

This form provides the ITU-T | ISO/IEC Joint Video Coding Experts Group (JVT) with information about the patent status of techniques used in or proposed for incorporation in a Recommendation | Standard. JVT requires that all technical contributions be accompanied with this form. *Anyone* with knowledge of any patent affecting the use of JVT work, of their own or of any other entity ("third parties"), is strongly encouraged to submit this form as well.

This information will be maintained in a "living list" by JVT during the progress of their work, on a best effort basis. If a given technical proposal is not incorporated in a Recommendation | Standard, the relevant patent information will be removed from the "living list". The intent is that the JVT experts should know in advance of any patent issues with particular proposals or techniques, so that these may be addressed well before final approval.

This is not a binding legal document; it is provided to JVT for information only, on a best effort, good faith basis. Please submit corrected or updated forms if your knowledge or situation changes.

This form is *not* a substitute for the *ITU ISO IEC Patent Statement and Licensing Declaration*, which should be submitted by Patent Holders to the ITU TSB Director and ISO Secretary General before final approval.

Submitting Organization or Person:	
Organization name	**Nokia, Inc.**
Mailing address	**6000 Connection Dr., MS 3-4-1400** **Irving, TX 75039**
Country	**USA**
Contact person	**Justin Ridge**
Telephone	+1 972 374 0628
Fax	
Email	Justin.Ridge @ nokia.com
Place and date of submission	11 October, Nice, France
Relevant Recommendation | Standard and, if applicable, Contribution:	
Name (ex: "JVT")	
Title	
Contribution number	

(Form continues on next page)

Disclosure information – Submitting Organization/Person (choose one box)

☐ 2.0 The submitter is not aware of having any granted, pending, or planned patents associated with the technical content of the Recommendation | Standard or Contribution.

or,

The submitter (Patent Holder) has granted, pending, or planned patents associated with the technical content of the Recommendation | Standard or Contribution. In which case,

☐ 2.1 The Patent Holder is prepared to grant – on the basis of reciprocity for the above Recommendation | Standard – a free license to an unrestricted number of applicants on a worldwide, non-discriminatory basis to manufacture, use and/or sell implementations of the above Recommendation | Standard.

☐ 2.2 The Patent Holder is prepared to grant – on the basis of reciprocity for the above Recommendation | Standard – a license to an unrestricted number of applicants on a worldwide, non-discriminatory basis and on reasonable terms and conditions to manufacture, use and/ or sell implementations of the above Recommendation | Standard.

Such negotiations are left to the parties concerned and are performed outside the ITU | ISO/IEC.

X 2.2.1 The same as box 2.2 above, but in addition the Patent Holder is prepared to grant a "royalty-free" license to anyone on condition that all other patent holders do the same.

☐ 2.3 The Patent Holder is unwilling to grant licenses according to the provisions of either 2.1, 2.2, or 2.2.1 above. In this case, the following information must be provided as part of this declaration:

- patent registration/application number;
- an indication of which portions of the Recommendation | Standard are affected.
- a description of the patent claims covering the Recommendation | Standard;

*In the case of any box **other than 2.0** above, please provide the following:*

Patent number(s)/status _____

Inventor(s)/Assignee(s) _____

Relevance to JVT _____

Any other remarks: _____

(please provide attachments if more space is needed)

(form continues on next page)

Third party patent information – fill in based on your best knowledge of relevant patents granted, pending, or planned by other people or by organizations other than your own.

Disclosure information – Third Party Patents (choose one box)

X 3.1 The submitter is not aware of any granted, pending, or planned patents *held by third parties* associated with the technical content of the Recommendation | Standard or Contribution.

☐ 3.2 The submitter believes third parties may have granted, pending, or planned patents associated with the technical content of the Recommendation | Standard or Contribution.

For box 3.2, please provide as much information as is known (provide attachments if more space needed) - JVT will attempt to contact third parties to obtain more information:

3rd party name(s) _____

Mailing address _____
Country _____
Contact person _____
Telephone _____
Fax _____
Email _____
Patent number/status _____
Inventor/Assignee _____
Relevance to JVT _____

Any other comments or remarks: