Selective and Scalable Encryption of Enhancement Layers for Dyadic Scalable H.264/AVC by Scrambling of Scan Patterns

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Problem Statement

THE PROBLEM:
- To devise a method for selective and scalable encryption (SSE) of intra dyadic scalable coding framework based on wavelet/subband (DWTSB) for H.264/AVC.

OUR APPROACH:
- Separate secret key has been used for each layer. The key has been embedded in LL subband using fragile watermarking.
- Scalable encryption has been introduced, in accordance with the energy distribution of quantized transformed coefficients (QTCs) in the specific subband.
- SVC offers a new profile for intra video coding named Profile B Intra only.

H.264/AVC

H.264/AVC is the state of the art video codec and performs better than previous standards.

Scalable video coding (SVC) is based on H.264/AVC. Different SVC approaches have been used in literature: a) Pyramid coding used in JSVM, b) Wavelet subband coding used in JPEG2000, c) DWTSB for dyadic scalable intra frame of JSVM.

In this work, we have used DWTSB approach.

The Proposed Method

Scanning is a bijective function from \( P_{mn} \) to \( Q_{mn} \). Let the QTCs be a 2-dimensional array given as:

\[ P_{mn} = \{p(i,j) : 1 \leq i \leq m, 1 \leq j \leq n\} \]

After scanning the 2-dimensional array, we get a set:

\[ Q_{mn} = \{q1, ..., qmn\} \]

Every subband has different energy distribution. Hence, separate scan should be used for each scan. For example, in LL subband:

Energy distribution in QTCs of LL subband. Scan used for this frequency distribution.

Encryption is performed by scrambling of scan pattern of transformed coefficients as shown below.

Scalable SE has been used in which we have a compromise among required computational power, bitrate and PSNR of encrypted bitstream.

In each encryption level of SSE, we leave a subgroup of QTCs unscrambled, which depends on the DWTSB subband. Since in each subband QTCs have different energy distribution.

Subgroup of QTCs which is not scrambled in each encryption level is shown different energy distribution.

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Experimental Results

- We have used ‘JVT-W097’ which is referenced H.264 JSVM 8.9 with wavelet framework integrated.
- Daubechies 9/7 wavelet filter set has been used to transform the image to the wavelet subbands.
- CAVLC entropy coding mode has been used.
- Analysis of trade off among bitrate, PSNR and SE level for city over whole range of QP values.
- Analysis of change in bitrate and PSNR without encryption and with SSE of benchmark video sequences at QP value ‘12’.

Framework Analysis

- Frame-wise analysis of 2nd EL at 4CIF resolution with QP value ‘18’ of city: a) Frame size, b) PSNR.

Visual Analysis

- Subframe of 280 × 240 pixels with offset of (400,200) in original frame of 2nd EL (4CIF) from 1st frame of city at QP 12: a) Without encryption, b) With SSE.

Conclusion

Encouraging results in the following contexts:
- Protection of different layers of spatially scalable bitstream.
- Real-time constraints have been achieved as:
  - No increase in bitrate. Hence it can be used in streaming applications.
  - It can be used for handheld devices as there is negligible increase in processing power.
- The encrypted bitstream is completely decodable.