Watermarking in High Efficiency Video Coding (HEVC)

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Outline:

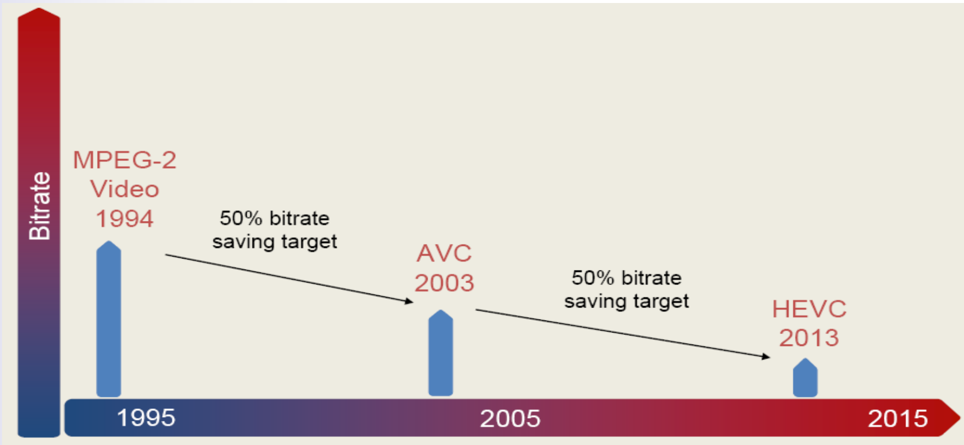
- Introduction
- Related Work
- Motivation
- Our Contribution
- Experimental Results
- Conclusion

High Efficiency Video Coding (HEVC):

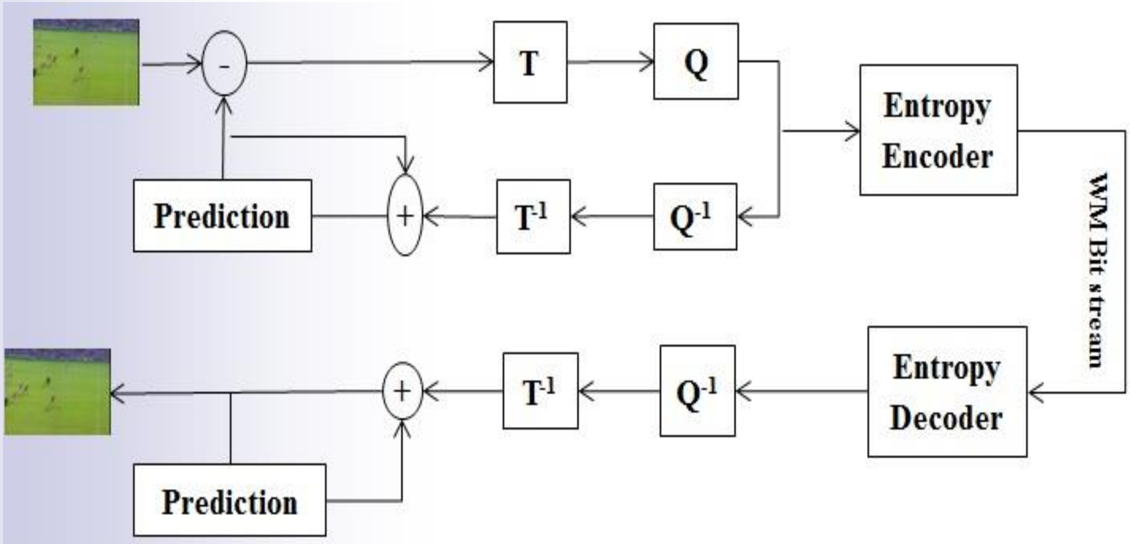
- New video Compression standard.
- Developed by JCT-VC Joint Collaborative Team on Video Coding of ISO/IEC MPEG and ITU-T VCEG.
- Also Known as H.265.
- Approved As a Standard on 25th January 2013.
- It is Successor of H.264[1].

HEVC: Conti…

- Higher video quality.
- Support High resolution video up to 8k.
- 50% data rate reduction. As compared to H.264 [2].



HEVC Block Diagram:-



HEVC: Applications:-

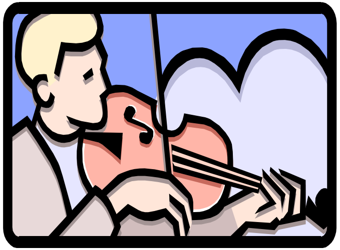
- High Definition (HD) TV signals over satellite, and cable
- Camcorders
- Blue-ray discs
- Security applications
- Internet and mobile network video
- Real time conversation applications such as:
  video chat, video conferencing [3].

Digital Watermarking:-

- Digital watermarking is the process of embedding information into a digital signal.
- Watermarking can be applied to digital signals [4].
- Imperceptibility
- Capacity
- Robustness

Image

Video



Audio

Related Work:-

- In literature several algorithms were proposed for watermarking in H.264 and other video coding standards.

- DCT based watermarking Methods.

Goliker et al[5], Gong et al [6], Wang et al [7], Zhang et al [8], Noorkami et al [9] and Russel et al. [10] uses DCT coefficient to embed watermark in H.264.

Alattar et al.[11], Barni et al.[12], Hartunq et al [13] and Langelaar et al.[14] also uses DCT coefficient to embed watermark in MPEG-2/4.

Related Work:-

- Video bit stream.

  Mansouri et al [15] and Langelaar et al.[16]

- MV-based watermarking scheme.

  Zhang et al.[17] , Liu et al .[18], song et al.[19], Bodo et al.[20] and Qiu et al.[21].

Problem:

- Significantly degrade video quality
- Very limited payload.

Motivation:-

- HEVC is an emerging video codding standard.
- Provide better compression efficiency as compared to previous standards.
- Internet technologies and multimedia are growing very fast.

- Digital contents can be very easily copied, modified, and redistributed. This has become a major concern for multimedia content owners.
- Watermarking can be used to protect the digital contents.

Contribution-I

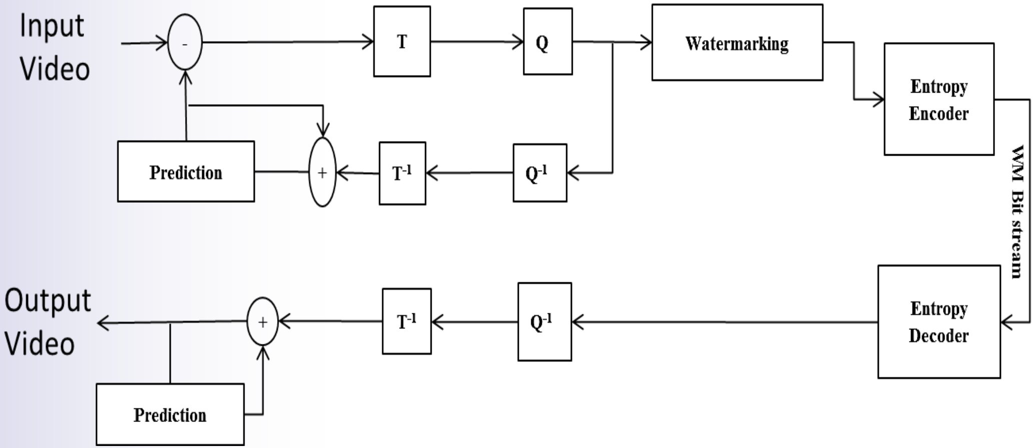
High Payload Watermarking Scheme for High Efficiency Video coding(HEVC)

Proposed Watermarking Algorithm:-

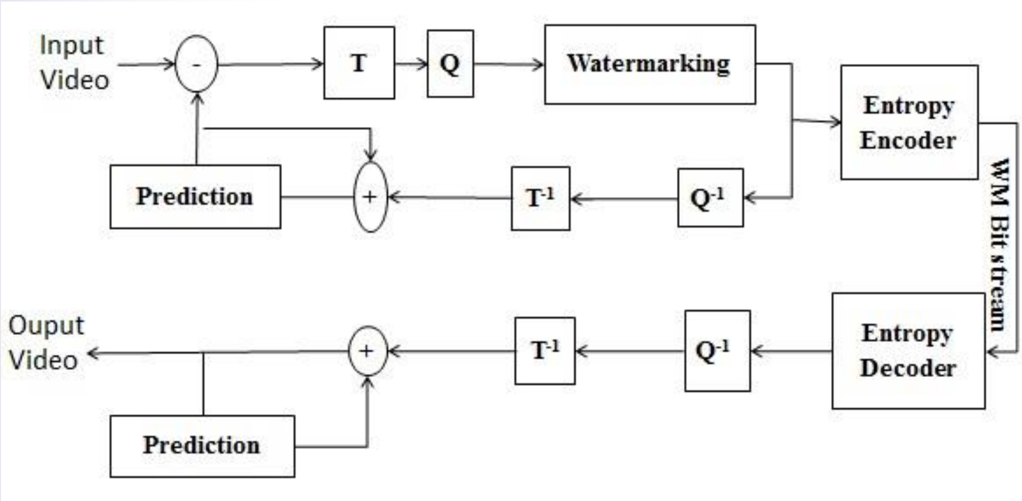
- DCT Domain
- LSB Algorithm
- For message embedding we consider the non-zero QTCs.
- First of all a certain threshold is selected and the watermark message is embedded in all those coefficients which are greater than threshold.

$$\begin{bmatrix} -10 & 4 & 1 & 0 \\ -7 & 3 & 0 & 0 \\ -5 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$ 4 x 4 DCT block.

Previous Embedding Schemes.:-



The Proposed Watermarking scheme for HEVC.:-



MESSAGE EMBEDDING SCHEME:-

- The process of embedding message in QTC is as follows:

$$\hat{Z}_w = f\ (\hat{Z}(i, j), M)$$

- We developed three schemes to embed message in 1LSB, 2 LSB and 1&2 LSB.
- For n LSB mode, the hidden message is embedded in a QTC in n LSBs if $|QTC| > 2^n - 1$.
- Algorithm 1 describes the embedding of 1 watermark bit (Wbit) in LSB of |QTC|.

Algorithm 1:

---

1. **If |QT C | > 1 then**
2. **|QT C | = |QT C | − |QT C | mod 2+ Wbit**
3. **End if**

MESSAGE EMBEDDING SCHEME:-

- Algorithm 2 illustrates the embedding of 2 bits in 2 LSBs of a QTC.

- QTC will remain unchanged if |QTC| < 4. If |QTC| > 4, it will get modified depending on whether Wbits are '00', '01', '10' or '11'.

Algorithm 2:

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1. **If |QT C | > 3 then**
2. **|QT C | = |QT C | − |QT C | mod 4+ Wbits**
3. **End if**

MESSAGE EMBEDDING SCHEME:-

- We can also perform a 1 & 2 LSBs embedding together. In this case, we embed message in 0, 1 & 2 LSBs depending on value of |QTC|, as shown in Algorithm 3.
- So we embed 2 Wbits if |QTC| > 3, or 1 Wbit if |QTC| > 1.

Algorithm 3:

1. **If |QT C | > 3 then**
2. **|QT C | = |QT C | − |QT C | mod 4+ Wbits**
3. **Else**
4. **If |QT C | > 1 then**
5. **|QT C | = |QT C | − |QT C | mod 2+ Wbit**
6. **End if**
7. **End if**

MESSAGE EXTRACTION SCHEME:-

- In the decoding process we use the following scheme to extract the message form QTCs.

$$M=h\,(\hat{Z}_w\,(i,\,j))$$

- Where h ( ) is watermark extraction process, $\hat{Z}_w$ (i, j)) is the watermark QTC and M is the message. Algorithm 4 and 5 presents the message extraction scheme for 1LSB and 1 & 2 LSB.

- **Algorithm 4:**

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1. If |QT C | > 1 then
2. Wbit=|QT C | mod 2
3. End if

MESSAGE EXTRACTION SCHEME:-

- **Algorithm 5:**

1. If |QT C | > 3 then
2. Wbits = |QT C | mod 4
3. Else
4. If |QT C | > 1 then
5. Wbit = |QT C | mod 2
6. End if
7. End if

Experimental Results:-

- HM 9.0 Source code
- Benchmark video sequences
- Performance is evaluated for 100 frames of each video
- Two values of QP 18 and 32.

Sq #	Sequences	Resolution	FPS
Sq 1	PeopleOnStreat	2560 x 1600	30
Sq 2	ParkScene	1920 x 1080	30
Sq 3	ChinaSpeed	1024 x 768	30
Sq 4	Video 1	1280 x 720	30
Sq 5	BQMall	832 x 480	30
Sq 6	RaceHorses	416 x 240	30

Experimental Results:-

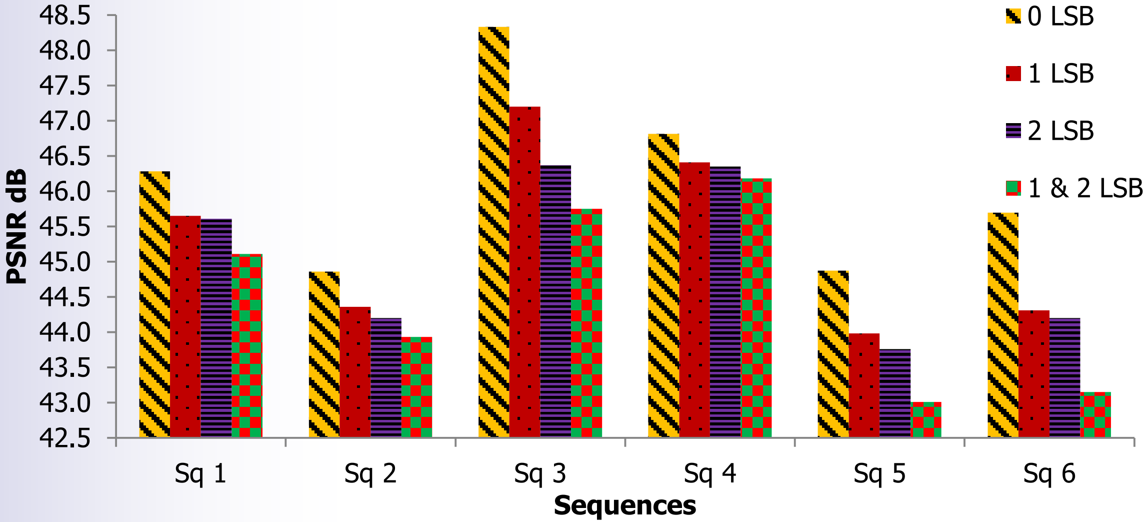
- Imperceptibility

$$PSNR = 10\ log_{10} \frac{255^2}{MSE}, \qquad MSE = \frac{1}{MN} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} \left(I\left(i,j\right) - I'\left(i,j\right)\right)^2.$$

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)}$$

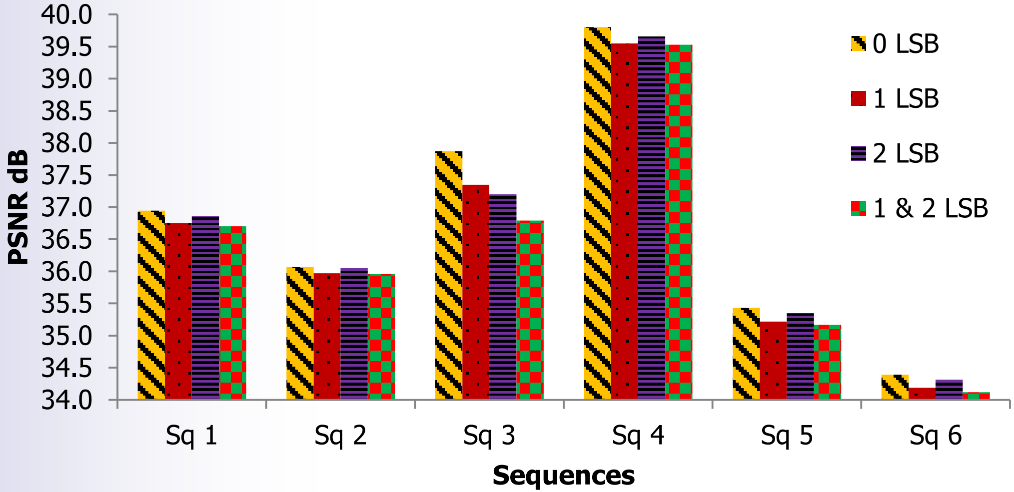
- Data Payload
- Frame Size

Experimental Results:- PSNR Comparison at QP 18



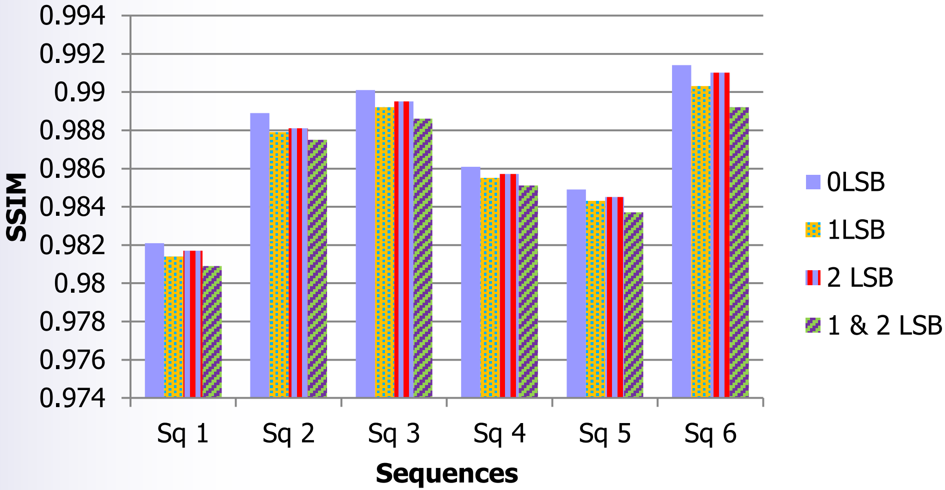
1LSB: 0.82 dB 2LSB: 1.06 dB 1&2LSB: 1.62 dB

Experimental Results:- PSNR Comparison at QP 32



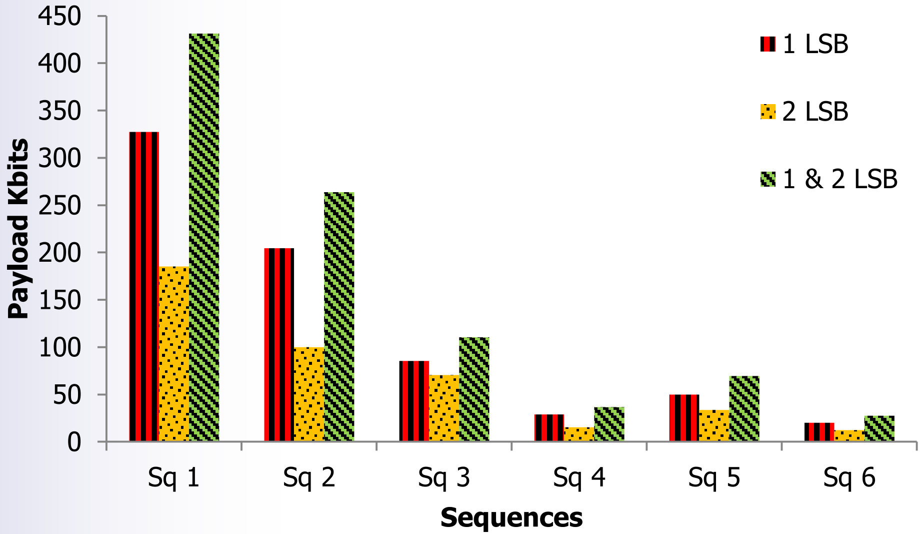
1LSB: 0.25 dB 2LSB: 0.18 dB 1&2LSB: 0.37 dB

Experimental Results:- SSIM Comparison at QP 18

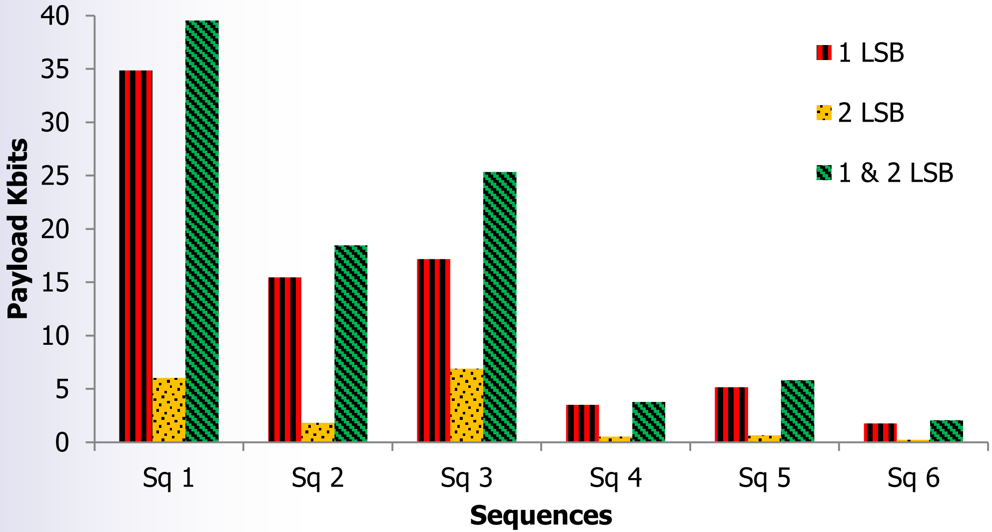


1LSB: 0.00082 2LSB: 0.00050 1&2LSB: 0.00124

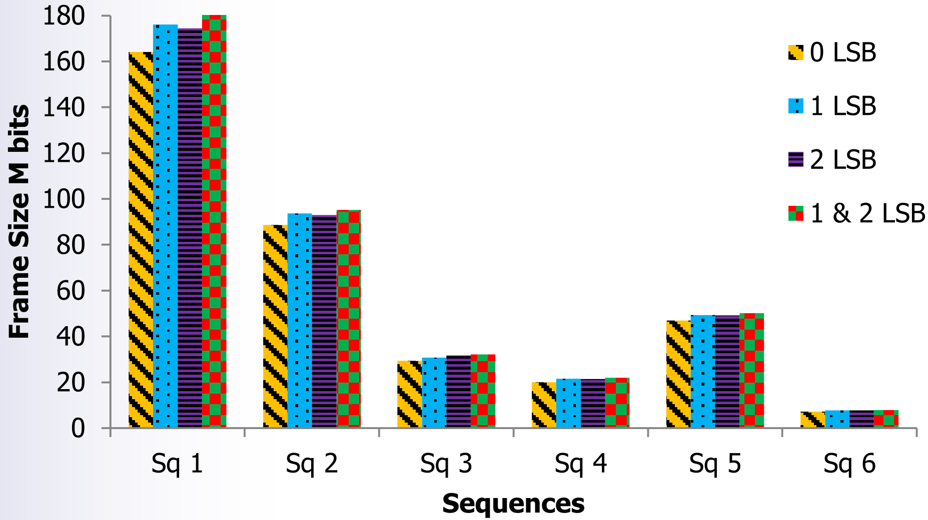
Experimental Results:- Payload Comparison at QP 18



Experimental Results:- Payload Comparison at QP 32

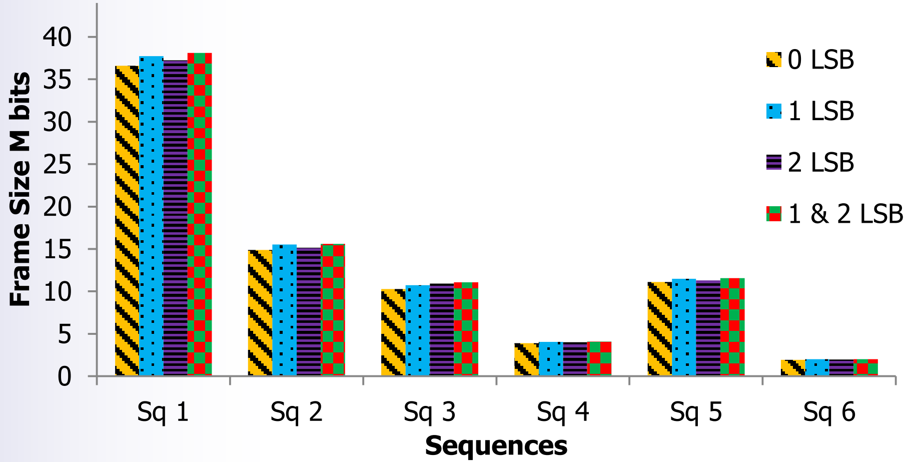


Experimental Results:- Frame Size Comparison at QP 18



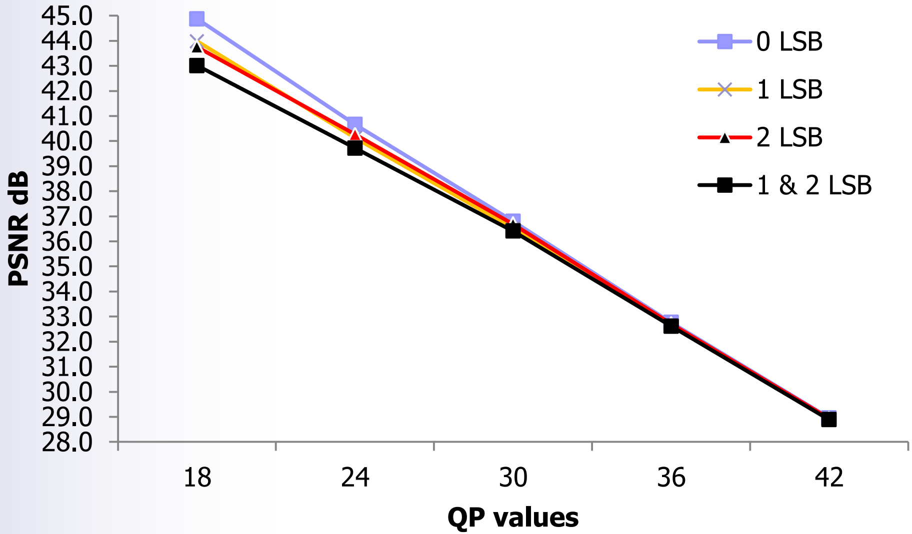
1LSB: 6.34% 2LSB: 6.44% 1&2LSB: 8.93%

Experimental Results:- Frame Size Comparison at QP 32



1LSB: 3.86% 2LSB: 2.33% 1&2LSB: 4.81%

Experimental Results:- PSNR Comparison at the whole range of QP values for BQMall video sequence.



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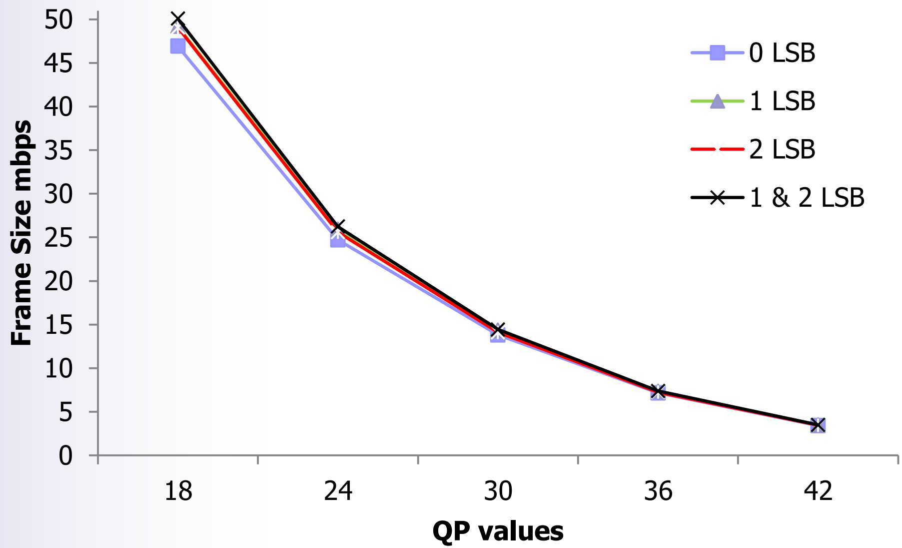

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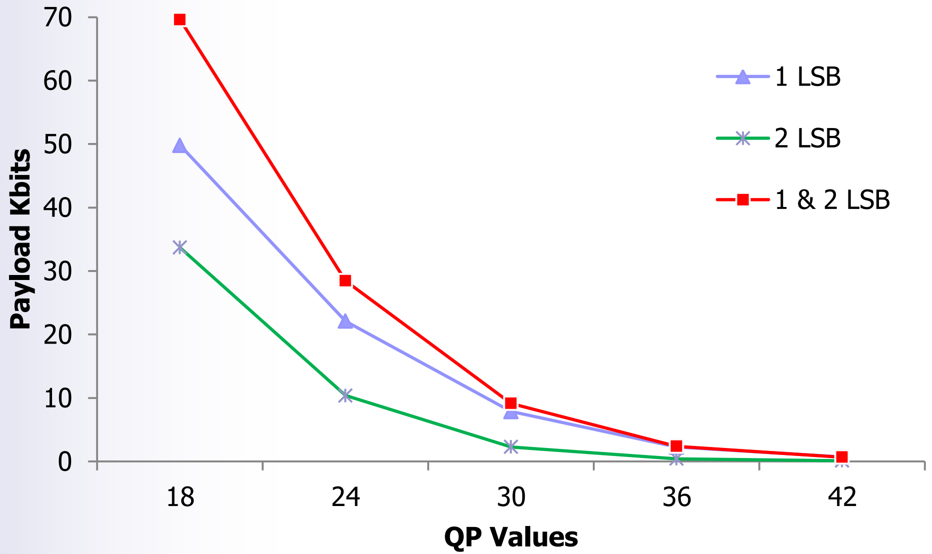


Contribution-II

Commutative Watermarking and Encryption of HEVC

Introduction:-

- Media encryption encrypts media data with ciphers
  - which protects media content's confidentiality
- Different from text/binary data encryption, video encryption often requires the scheme be time efficient and format complaint
- It is not practical to encrypt video data completely with traditional ciphers such as DES and AES

Introduction:-

- Selective Encryption(SE):-

Selective encryption encrypts some part of the data to get desired level of security and utilizes minimal computational resources.

- Partial Encryption(PE) :-

While in partial encryption, we encrypt only a portion of image (e.g., ROI), rather than encryption of the whole image.

Related Work:-

- Manicaam et al. [22] proposed a SE. In which they took difference of frames and encrypted the residual data. The drawback of this method is that the bitrate of video bitstream will rise by several times.
- In [23], Wang et al. have presented a SE scheme for H.264/AVC. They proposed to encrypt intra prediction mode, motion vector difference, and quantization coefficients.
- In [24], Zeng and Lei proposed to shuffle quantized transform coefficients across DCT blocks.
- In [25]. In this scheme, encryption of I frame is performed, since P and B frame have no significance without I frames.

Motivation:-

- Video encryption and video watermarking can be combined together to protect both the confidentiality and the ownership/identification
- Generally, it is implemented according to two steps
  - Firstly, media data are watermarked
  - Secondly, the watermarked media data are encrypted
- Media data must be decrypted before the watermark can be detected or another watermark can be embedded

Motivation:-

- If they are commutative, some computing cost will be saved
  - The watermark can be directly extracted from the encrypted media data
  - The encrypted media data can be directly watermarked
  - The watermark is embedded into the encrypted media data directly without knowing the decryption key, which avoids the leakage of media content

Proposed CWE Scheme:-

- In CWE scheme, the video data is partitioned into two independent parts: watermarking and encryption is applied on these parts independently.
- Let X be the multimedia data. X is partial into two independent parts Y and Z. The Y part is watermarked and Z part is encrypted. i.e.,

$$\acute{Y}_w = f(Y, W, K_w).$$

$$\acute{Z}_E = h(Z, K_E).$$

Proposed CWE Scheme:-

- **Watermarking Part:**

  The Scheme already explained

- **Encryption Part:**

  i. DCT Coefficients Signs

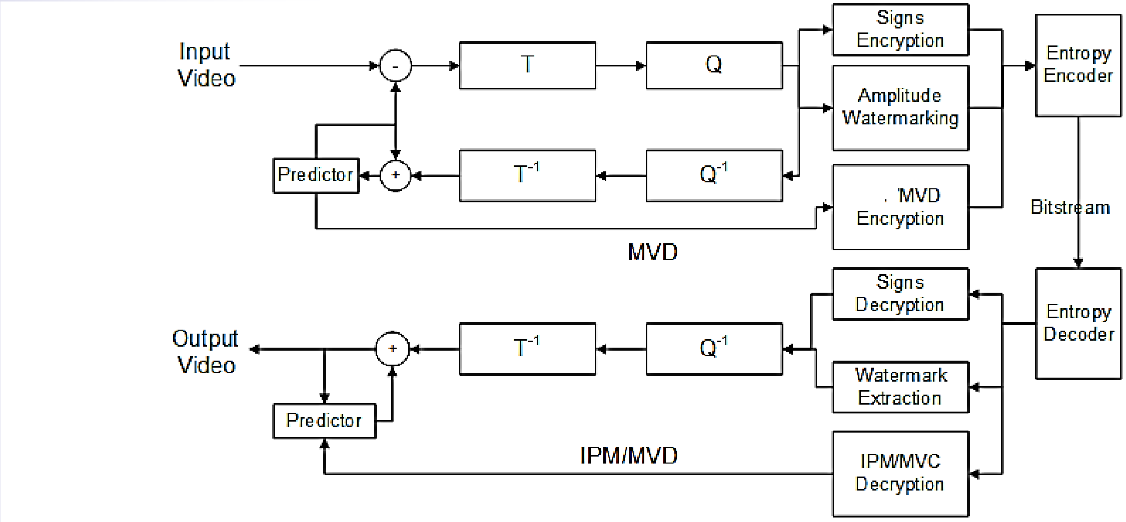
  For each non-zero DCT block, DCT coefficient signs are encrypted with a cipher.

  ii. Motion Vector Signs

  - For each block, the signs (“0”—positive, “1”—non positive) of MV [x, y] are encrypted with a cipher. That is, MV is encrypted from [x, y] to [x’, y’] with the following condition being satisfied:

$$\begin{cases} |x'| = |x| \\ |y'| = |y| \end{cases}$$

Proposed CWE Scheme:-



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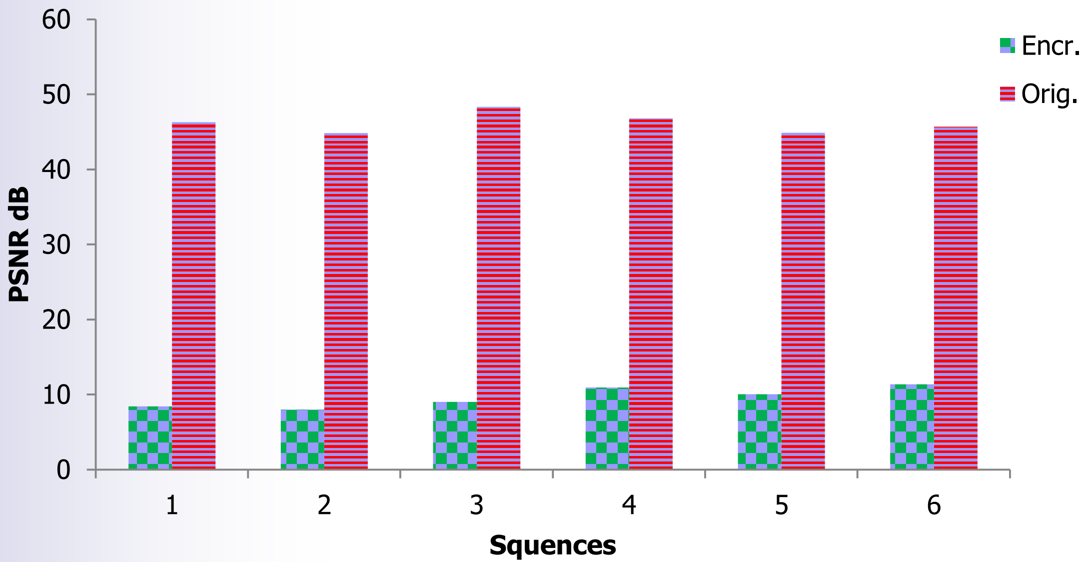
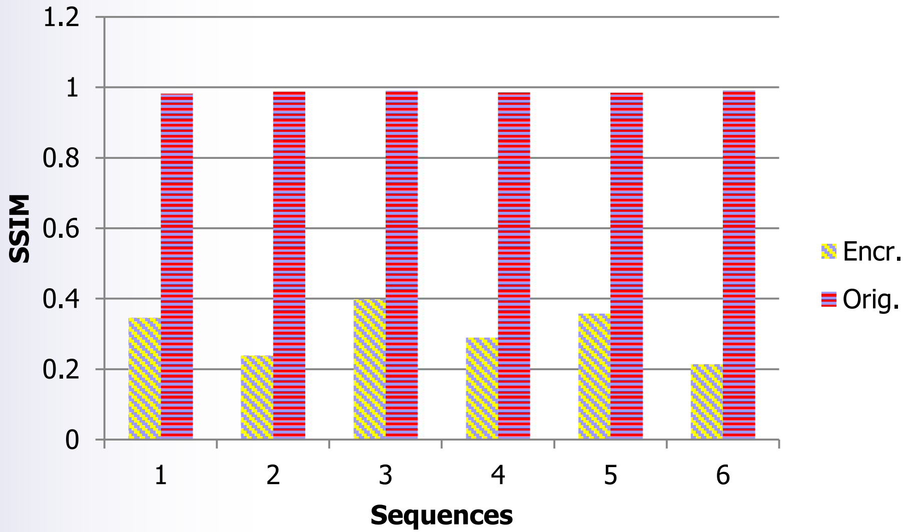


Experimental Results:-



Experimental Results:-

Conclusion:-

- **High Payload Watermarking Scheme for HEVC**

We proposed a high payload watermarking algorithm for emerging video coding standard HEVC. Least Significant Bit (LSB) algorithm is used to embed the watermark message in the QTC domain. The watermark message bits are embedded in all the non-zero coefficients which are greater than a certain threshold. The results show that proposed scheme is efficient because it does not increase the video file size and also does not affect the video quality significantly.

- **Commutative Watermarking and Encryption of HEVC.**

Encryption and watermarking process are independent. Suitable HEVC parameters are encrypted and watermarked separately. For encryption MVD signs and DCT coefficient signs are encrypted with a cipher and amplitude of DCT coefficients are watermarked. The presented scheme provides low computational complexity and format compliance. The experiments have shown that desired level of encryption and high capacity message embedding can be achieve through the presented scheme, without compromising the video quality.

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THANK YOU..