A Real-Time H.265 Codec

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Abstract: ***The increasing assortment of applications, rising publicity of HDevideos, and up-growth of beyond HD.format need a coding-impact preeminent than H.264ecapabilities. H.265 is a new fangled video coding principle. It has further intra-prediction directions than AVC but this increment increased the bit stream-overhead with the complexity of RDOEENTROPY codec. So this paper implements a real-time encoding/decoding process with a combination method between a proposed fast-technique forentropytoe partition LCU with providing a low complexity intra-mode prediction algorithm to enhance the mode prediction accuracy and computation speed. This is done by finding the relationship between the encoded-PU and its neighbours then encoding their index by a Shannon Entropy coding rather than RDO. Experimental results showed that the suggested technique reduces coding intervalto99% on average in comparison to HM6.0 with also a reduction in the computational complexity and an acceptable loss in the frame-quality.***

Keywords: H.264/MPEG-4 AVC, H.265, Fast encoding algorithm, entropy, RDO

1. Introduction

Over the last decade, the enhancements of digital video compression techniques leads to the prosperity of nowadays multimedia appliances such as 'smart phones', 'digitalETVs', and 'digicams'[1]. Since the current stereo's basis and multi-view video coding format isH.264Advanced Video Coding standard [2].It has widely implemented in a variety range of video products/services [3]. Nowadays peoples are seeking for a newfangled video codec's layout, giving superior performance than'H.264'and because of the great demand for higher resolution videos, HEVC aims at achieving a higher video quality than what H.264standard presents[4]. 'HEVC' is a draft standard under enhancement via **'Joint Collaborative Team** on **'Video Coding' (JCT-VC)**. It's a newfangled production of video squeezing technique with a compression capability reaches to about (50%) of information average needed for 'HD-VC' in comparison with (H.264) standard [5].HEVC can be useful for many fields such as real-time conversational application (Video chat, Video conferencing and Tele presence systems) promulgation of eHD-TV signals over satellite, cable and earthlier transference Systems, Video acquisition/ rectification

Systems, applications, Internet and mobile NET video, BD-Discs [6].It have the same basic structure regarding the previous codec unless some new improvements such as:

- More flexible partitioning
- Greater flexibility in Prediction modes and TB sizes
- More expansible interpolation and de-blocking filter.
- More sophisticated prediction and mode's signalling.
- Capabilities to support parallel processing.

Therefore as we mentioned before, it can enable better compression with some comparable increased power. A significant divergence betweenH.265&H.264 is the frame coding basis [7]. In H.265 each frame splits into the basic processing unit scheme called 'Largest coding units' (LCUs) [8]; that consecutively split to tiny Coding tree Units (CUs) by the use of a comprehensive quad-tree splitting layout that indicates the subdivision of the CU for 'Prediction/Residual 'coding which later be split into predictions reunites (PUs) for intra/ inter prediction and transformed unites (TUs) form Transform/Quantization as it is obvious in fig. 1.

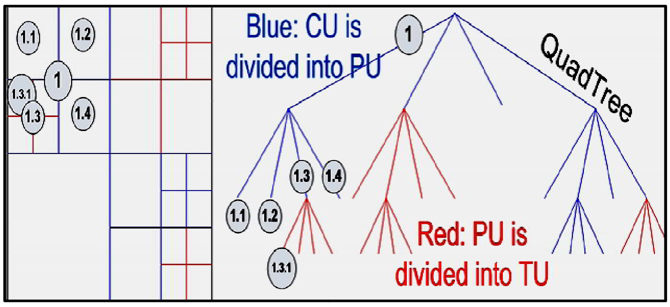


Figure 1: H.265 Structure

However, in the previous codes each frame is partitioned into '16x16emacroeblocks', and then divided into 'tiny blocks' (asesmallease4x4) for prediction [9]. As the frame resolution of videos growing more and more from '**SDetoeHD**' & further.

The opportunities for 'high efficiency' encoding with 'Large Smooth' sections/picture can be possible. [10].Fig. 2presentsprediction modes and CU'seframework. This is the reason behind why H.265 can support much larger encoding blocks in comparison with'H.264',since it has a more adaptable partitioning scheme[11].

Therefore, it has been developed in order to target the ultra-high resolution with higher frame rates compared to' H.264/MPEG-4

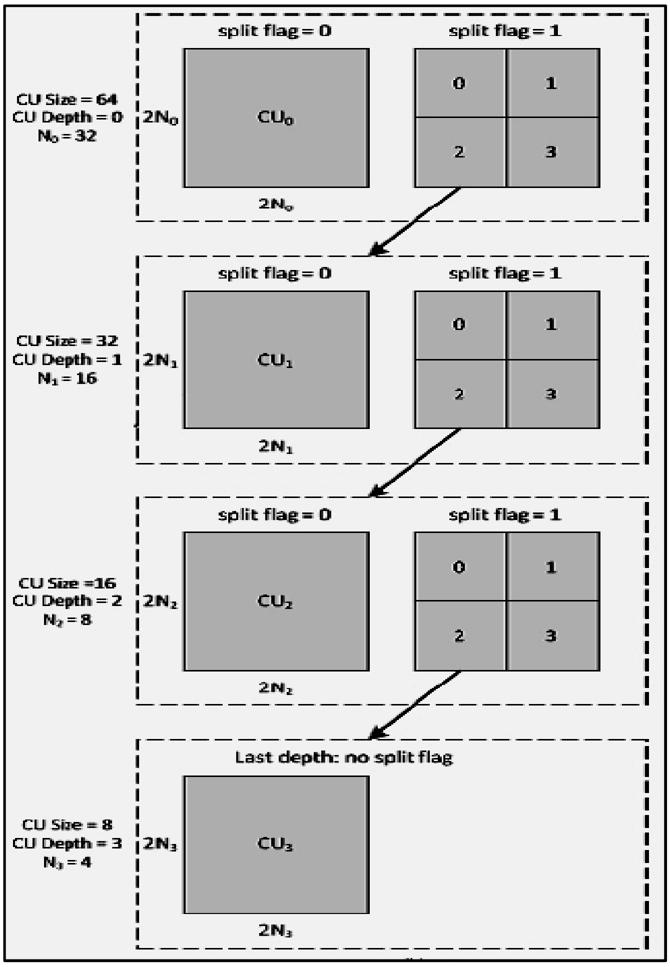


Figure 2: Recursive-CU structure & depth level's modes

In'H.264/AVC' context of some syntax elements (e.g. EMVD) depends on top and left values [12]. The dependence on top values requires large line buffers, and that may be an issue for superior resolutions such as 4k. In H.265 the dependence on top-neighbours (outside of current-CTU) is significantly reduced [13].

For example, unlike toe'H.264', in H.265 'mvd' is coded without the need of knowing (neigh-boring mvd) values; therefore there will be a reduction in memory. H.265has tiles to uphold parallel processes more adjustable than ordinary slices in'H.264'; but considerably minimal intricacy than flexible macro-block ordering (FMO) [14].

Vertical/HorizontaleEdges define Tiles with intersections split a frame into 'Rectangular Divisions'. 'Entropy's-Slices 'are the subdivisions/slice in H.265 to strengthening parallel processing [15]; that can be independently 'Entropy 'Decoded'. Subsequently, they can be treated by each CPU's core in parallel. Intra Prediction has a substantial role in H.265 as inH.264; but with extra features to raise its qualification[16]; like the numbers of prediction types are no less than'5' from(64x64)to (4x4) instead of'3'in H.264(from16x16) to(4x4)[17] and(34'AngularePrediction')modes rather than'9'in 'H.264' as shown in Fig. 3. The 'Intraday Prediction' angles are±[0,2,5,9,13,17,21,26,32].

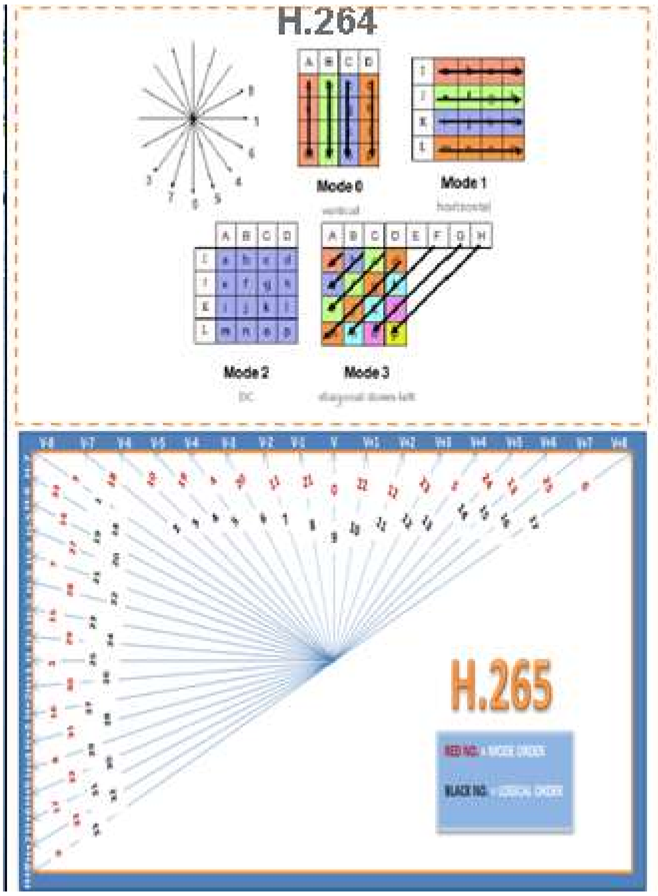


Figure 3: H.264, H.265 Angular prediction modes

Obviously, these features has resulted significantly a higher complexity for intraprediction.H.265 has been prepared to manage mostly all nowadays'H.264'services and concentrating one-two issues: raising video resolution land parallels processing framework usage. Thee retarget of this work is to develop H.265to be faster and suitable for real-time systems.

2. Video Codec Complexity

The encoding process is by far the most complex part of the system. This complexity is caused by the large variety of options the encoder can utilize when encoding a certain area in the image. Although the encoder is free to use a very low complexity subpart of specified codec, making use of the full potential of a codec will eventually result in more efficient compression and the structure of the HEVC codec is shown below.

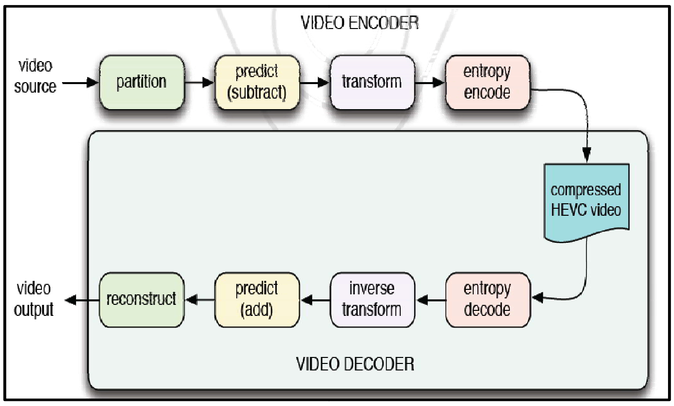


Figure 4: H.265 encoder/decoder

HEVC/H.265 standard has increases the computational complexity of H.265 decoder bye**'1.6x'**eand H.265 Encoder by '**4.5x**'ecompared to the 'H.264'estandard and to explain the complexity of a block based video encoder terminology as used inH.265 [3] will be used. In general, the principles behind 'H.264'eencoding and H.265 encoding are re-assembling.

In H.265, an image's slice is sectioned into 'LCUs' of64x64 pixels processed in araster scan manner. Each one of them can then be divided in CodingeUnits (CU) according to a quad-tree structure. Three levels of quad-tree division can be applied until reaching a minimum CU size of (8x8). Any combination of quad-tree splitting is allowed, resulting in (83522) possible quad-tree structures. An intra or inter prediction type is determined forever leaf CUeof the quad-tree.

The leafeCUis then filled up with PUs. The CUecan be regarded as one PUeor split in 4 smaller PUs for an intraeCU. Depending on the size of the PU, up to 35e intraePrediction modes can be chosen, and that made the encoder computation more complex even it is more precise than the previous codec. On the other hand, when the leafeCUeis an inter-codedeCU, 8 different partitioning structures are available. On these square or rectangular partitions MotioneCompensatedePrediction (MCP) is applied. For a typical encoder, the motion estimation process has the highest impact on encoding time. Also the processed BiteWidth of each data and how the algorithm operates can have a considerable effectiveness. Executing less operations doesn't necessarily means a bestead performance; instead may be '4'parallelyexecuted activities rather than 3 beequicker/less' complicated than threeeserially.

Besides, to predict a block size ofeNxN, AngularePrediction needs a calculation of**{p=(u.a+v.b+16)e>>e5/ensample}**that requires 2 multiplications (8-biteunsigned operands,16-biteresult), two16-biteadditions with one 16-biteshift/PredictedeSample(5eTotaleOperations); while in previous codec**{p=e(a+2.b+c) e>>e2}**, that may be regarded also as(5eOperations). Although, on some techniques these processes may work using 2e (8-bit) to halvee the add operations :**{ p=e (d+b+1) >> 1 and d=e (a+c) >> 1}**. Thus H.264 which is the previous codec has less complexity that needn't multiplications or median amount larger than 9-bite.

For the **Sample Adaptivee Offsete** (SAO) filter, the encoder has to decide on an efficient quad-tree partitioning. For SAONE filtering, (SAO) type and offset are decided and signalled by the encoder and the last filter to be applied is the Adaptive Loop Filtered **(ALF)**. First, the encoder can calculate up to 16diversified filters for utilization and per CU , the encoder needs to decide which filter is more useful to be used in order to get the best Rated Distortion (RD) result. With the current H.265-encoder implementations, then **(ALF)** filter takes up the largest amount of processing power from all filters.

3. Principles of the Proposed Algorithm

The proposed method combines both a modified way for intra-coding mode signaling with a replacement EENTROPY method faster than the original one. As it is known that H.265 supports a 34 intraprediction directional mode made it more superior than the previous codec 'H.246' but with a higher complexity and more overhead. So instead of treating all the directional more equally the same, a ranking list was made to speed up the calculation process with an overhead reduction. The procedure is demonstrated as follows:

1. Regarding the To NeighborePrediction Unit as a start point to build up a rank table for the prioritized directions beginning with the intra-mode number in logical manner. Since mode-1 and mode+1 give modes equal to the considered one according to Fig. 3, so we have chosen the mode-1 as the one with the highest priority.
2. Repeating the same procedure but in this time fortthe LeftiNeighborePrediction Unit. Regarding Fig. 5 as an example, we see that any duplication occurs between top and left neighbor is removed.
3. Merging the two lists of top and left-neighbor into one list. In addition to that, the horizontal-modes used in the LeftieNeighboredPU has a higher chances than the current one and also the same way is for the vertical-modes used in the TopsS NeighboredPU. Each chosen mode in the merged priority-list has a rank to be used in the bit-stream.

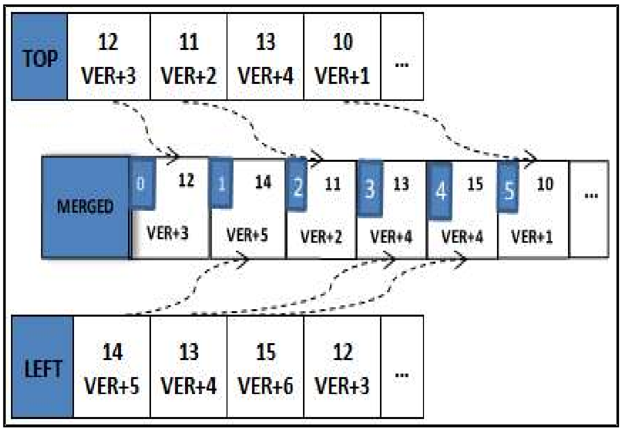


Figure 5: Example of the Proposed Algorithm

4. The rank is entropy coded using Shannon Entropy' method and mixedcrank index will be once computed/PU, thus an overhead-reduction will be obtained in the encoder impact process.
5. Finally, using a UNARYEBINARIZATION rather than a binary-form leads to a higher compression gain; because of the lesser bits representation in the entropy's coder.

The illustrated method is applicable if there is a left-top Prediction Units. Therefore to eliminate the fixed-length mode used for AngularIntra Prediction mode (IPM), the ranking table is used for all codec configurations so we can gain an extra compression deficiency for coding (IPM).

As we mentioned before that we used Shannon's Entropy method to encode each rank; but before doing this operation we need to make a stepper quantizer to have a suitable value approximately closer to the one resulted from Rate Distortion Optimization (RDO); which is the original entropy's method in H.265 codec. By using a fast low-complexity method in a quantization process leads to more time reduction and recuing the background noise. From diversity origins a noise will appear with a 'digital' or 'ConventionallFilm' cameras. Several factors should be considered in noisee reduction such as:

- The obtainable PC power and consumed-time.
- Whether it's OK to lose some real detail for more 'Noise Reduction'.
- The properties of 'Noise image' detail improve making those decisions.

By dividing each pixel value by the numbered (8) to quantize the frame; thus the maximum pixel value will be (32) in a range off (0-31). So instead of a range value (0-255), it will beef (0-31) making the entropy' calculations faster and easier. A reduction in discreet paradigms 'numbers/stream will be obtained with this process, to be further compressible (ex. minimizing the amount of colors to define an image allows minimizing in the image file's size). Using a fixed 'Framed Level Quantizer' does not grants a steady quality's level but will give a somewhat varying level counting on the frame's content. The entropy 'value for all possible CUs in the LCU was calculated using the Shannon Entropy' formulae from Galileo Imaging team as shown below:

$$\mathbf{H(x)} = -\sum_{k=0}^{n} P_k \times log_2(P_k) \quad (1)$$

Where:
H(x): *ENTROPYE*
P_k: *The probability that the differenceoff2adjacente pixels=k'.*
Log_2: *Base2 Logarithmic*

And by counting the number of appearance's possibility for each pixel in a CU, we could calculate the ENTROPY value. The equation used to calculate the probability P_k is shown below; (Which is used to find a relation-ship between the selected CUs and their entropy values):

$$P_k = \frac{\mathbf{n}_k}{\mathbf{N}} \quad (2)$$

Where:

N: *No. of pixels/CU*
N_k: *No. of pixels whose value=k*

Hence the image entropy's is for defining the business of a picture, (i.e. the quantity of data to be coded by a compression algorithm). Since a little contrast means low entropy's land series of pixels have similar DN magnitudes. Consequently, it's possible to be squeezed to a comparatively small size. Therefore, according to the relationship found between each CU and its entropy's, then there is no need for partitioning if its entropy's is so small and vice versa; but for the average value offCU's entropy 'typically appear in the final partition map.

Therefore the partitioning process will be hold right away after the entropy calculation and having suitable entropy threshold. So the average threshold that is chosen to have the highest-likeness between the suggested and enhanced CU'sleis the value that gives an average of all entropy'sberates/ LCUEin (1.2-3.5) range. So no partitioning process if the CU's entropys smaller than (1.2) or (0.15) bigger/lesser than the average while the partitioning process will be held if it's greater than 3.5.

4. Experimental Results

The proposed algorithm is experimentally evaluated and tested upon a sequence of frames that are captured using a digitalecamera.e'AlleIntraeMaine' Settings of Highe Efficiency coding parameters used as illustrated in [20] with a 'QuantizationeParameter 'value equal to 32. The encoding time in the proposed algorithm issued as a measure of complexity and all-test's outputs are compared to the test model'HM6.0'with the use of a computer of 2.0 GHz core. Therefore, to compute the time gain used to determine the suggested-technique's activity, the following equation has been used:

$$\Delta T = \frac{T_{\mathbf{HM6.0}} - T_{Proposed}}{T_{\mathbf{HM6.0}}} \quad (3)$$

Where:
$T_{HM6.0}$: *HM6.0 Coding Timed with RDO*
$T_{proposed}$: *ModifiedH.265 Coding Timed*
ΔT: *Time's Reduction*

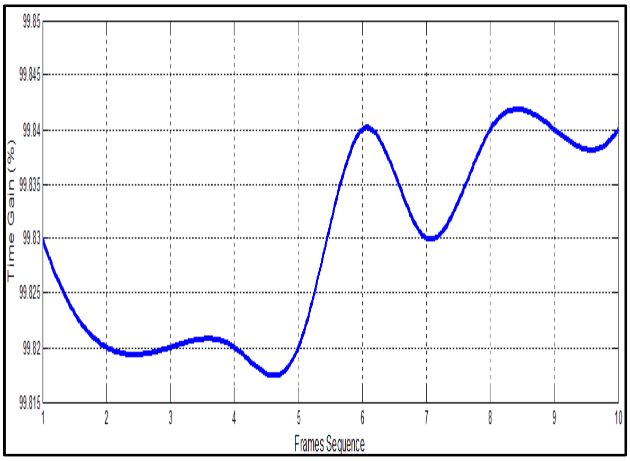
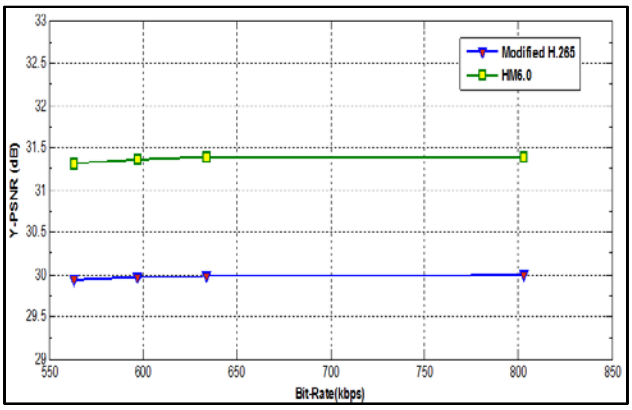
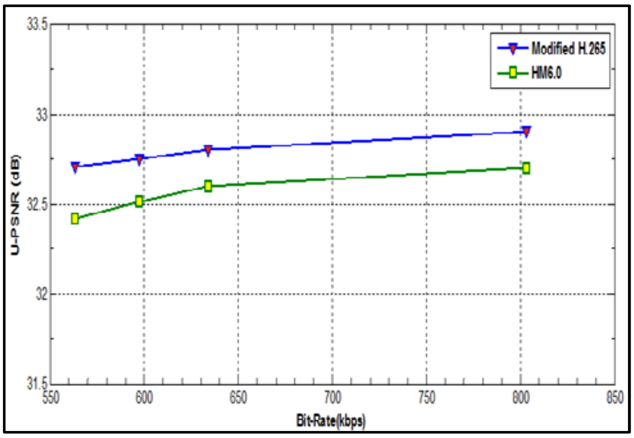


Figure 6: Time Gain vs. Frames Sequence

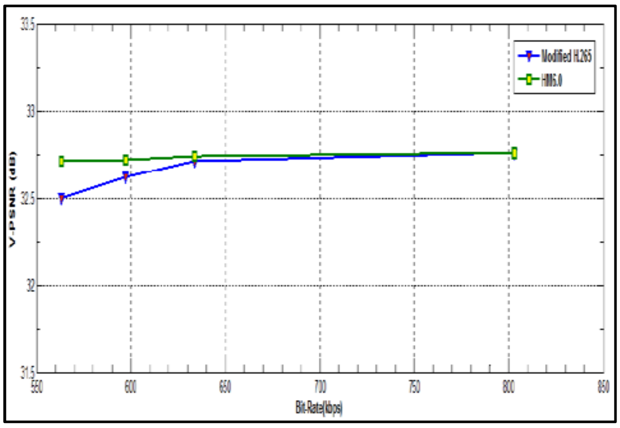
Fig. 6 shows that there is a reduction in time about 99% in average with a compression gain about 2.787. While Fig. 7 shows theePSNR comparison curves between 'HM6.0' and the proposed algorithm (PSNRe vs. Bit-Ratee (kbps)).



(a)



(b)



(c)

Figure 7: Experimental results of Camera Captured frames (CIF)
(a)YEPSNR vs. Bit-Rated (Kbps); (b) UEPSNR vs. BIT-RATED (Kbps); (c) VEPSNR vs. Bit-RATED (kbps)

The curves show that the proposed algorithm's curves were nearly close to the 'HM6.0'curves, but for YePSNR it was better according to 'HM6.0'with small LCUe '32x32'.

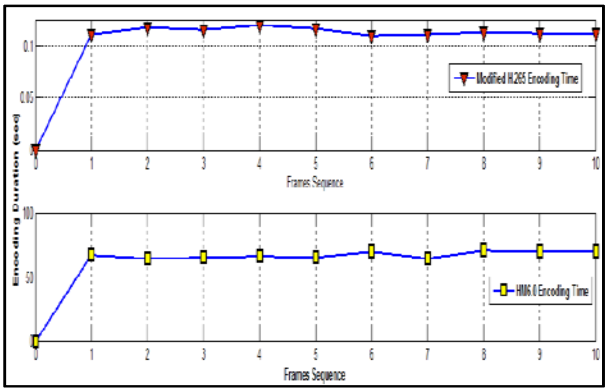


Figure 8: Encoding Time Comparison

Figure 8 shows a comparison in timeeencoding between the mentioned encoders.

5. Conclusion

In this paper, we suggested a combination method between low-complexity intra-mode predictions with an entropy algorithm that replaces the original one in H.265 model. So it combines the favourable mode flag and intra mode signalling into 1 method depending on the prioritization of different modes and encoding them using a Shannon 'Entropy's rather than RDO. The suggested techniques for E-COMPUTATION complexity/ Time Duration's reduction, considering also some acceptable loss in the frame quality. Based on the results shown before, the encoder can be performed faster with a high efficiency.

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