Performance Evaluation of H.264 Codec

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ABSTRACT
H.264/AVC is the most popular standard of video compression and decompression today, encapsulating all the advantages of MPEG as well as VCEG, both of them having their own independent codecs. The software used for compression and decompression is JM [Joint Video Team (JVT) of ISO/IEC MPEG & ITUT-T VCEG] version 18.2. This paper is a study of H.264 codec. The yuv file is first encoded to h.264 format. Some other output files are also generated, which are useful for overall analysis of the input yuv file or sequence. These files help us to analyze parameters like PSNR, sequence parameter set, picture parameter set, information about different frames as regards slices and macroblocks. In this paper, all the three profiles (baseline, main and extended) are operated for the sequence (foreman_part_qcif.yuv) with one reference frame. A quantization parameter for the I, P and B slices is taken as 30. The graph of bitrate vs. PSNR (rate distortion curves) in all the three profiles show a striking similarity as can be seen in figures shown below.

Keywords-H.264, PSNR, compression, decompression, profiles, Performance et. al**.**

1. INTRODUCTION
Video and image compression has become a very important part in communication, broadcasting and storage. In transferring video from source to destination many processes are involved out of which, compression (coding) and decompression (decoding) are the two important processes. ISO MPEG and ITU VCEG developed many standards. The very first standards in 1993 were the MPEG 1 and MPEG 2 developed by MPEG which were used for coding video and audio. MPEG 7 and MPEG 21 are the other standards and describe the audio visual content and a generic multimedia framework respectively. In 1998 VCEG was responsible for the H.261 widely used for video conferencing and later, its successor H.263. The two groups set up the joint video team collaboratively and prepared international standard H.264/MPEG4 Part 10 Advanced Video Coding (AVC). The overview of technical features of H.264/AVC is taken in [5], [11] and [12] describing the profiles and applications for standard. Also the history of the standardization process is also overviewed. In [12], some key advantages of H.264/AVC such as bit rate savings up to 50%, high quality video, error resilience (providing tools necessary to deal with packet loss), network friendliness (bit streams can be easily transmitted over networks) are mentioned. In [6], the description of H.264's basic concept is written in short although it cannot be considered as a replacement of the full fledged H.264 standard document. Iain Richardson in his books [1], [2], [3], has explained the codec's all views very nicely. He has contributed a lot for video compression in the form of books. The technology behind the new H.264/MPEG4-AVC standard is discussed in [7] along with the main distinct features of its core coding technology and its first set of extensions, known as the fidelity range extensions. The scalable extension of H.264/MPEG 4 part 10 AVC is a current standardization project as H.264/SVC (Scalable Video Coding). It is a very active area in research community and in international standardization. Performance of the video coding standards goes on increasing from MPEG1 onwards as well as from H.261 onwards [3].

This paper is organized as follows. The brief introduction of H.264 codec is given in section 2. It explains clearly the input output file of encoder and decoder. Section 3 describes graphically the performance of the three profiles. Conclusion is drawn in section 4.

2. THE H.264 CODEC
H.264 defines the syntax of an encoded bitstream and also the method of decoding it. Video compression or video coding is the process of reducing the amount of data to represent a digital video signal before transmission or storage. Prior to display the complementary operation i.e. decompression or decoding recovers the digital video signal from compressed signal. The compressed video clip takes up less transmission bandwidth or a less storage space. The basic unit is a macroblock and the subunit is a block. The macroblock contains 26 blocks [3]. H.264 has different profiles as baseline, main and extended profiles. Levels define the performance limits such as sample processing rate, picture size, coded bitrate and memory size. The 4:2:0 video format is used in codec. Y the luminance component, blue and red chroma i.e. cb and cr are transmtted with cb and cr ech have half the horizontal and vertical resolution of Y . The output of the encoding process is a VCL (video coding layer) which can be mapped to NAL (Network Abstraction layer) prior to transmission or storage. The encoder may use one or two of a previously encoded pictures as reference picture which enables the encoder for the best match for the current macroblock partition from a wider set of pictures [1]. The block diagram in fig 1 indicates as the input video and different output files from codec.

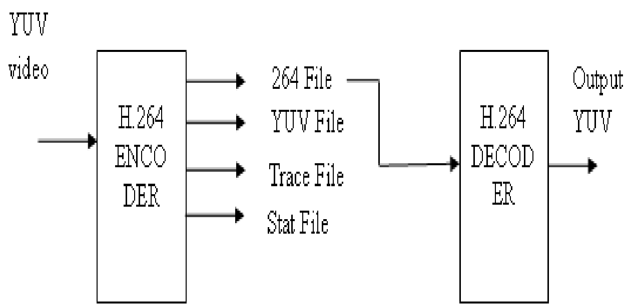

Fig 1: Block Schematic for H.264 codec

The input frame is from the foreman sequence (foreman_part_qcif.yuv) which is in YUV 4:2:0 format as shown in fig 2. The original video size for the three frames is 112 KB.

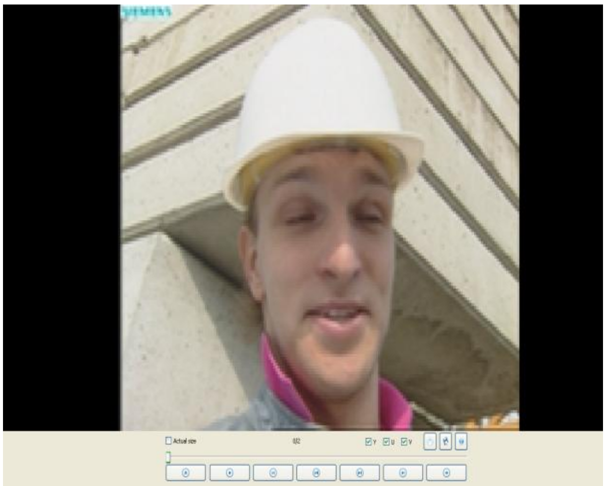

Fig 2: Frame from foreman sequence.

Then the four output files are created as shown in fig 1. The 264 file shown in fig 3 is when applied to decoder produces the same video sequence in YUV 4:2:0 format with the original size as 112 KB where as compressed 264 file has a size of 4KB. The trace file gives the description about sequence parameter set, picture parameter set; slice data description as per the Annex B [9] as can be seen in the fig 7. The general statistics for the file is also shown by the encoder in stat file in fig 8.

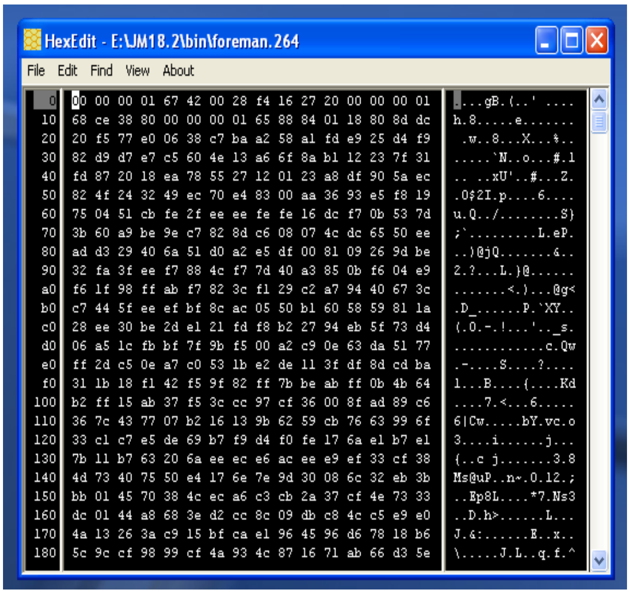

Fig 3: 264 File from the Codec

3. RATE DISTORTION PERFORMANCE

3.1 Baseline profile

H.264 is operated for baseline profile on the YUV file of foreman sequence. The single reference frame is used for predictions. The foreman sequence is encoded with different bitrates and the graph is shown in fig 4. In this profile the first frame is an IDR and next frames are P frames as per the constraint of baseline profile.

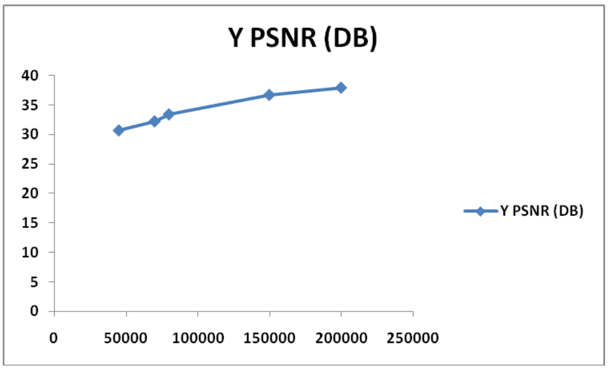

Fig 4: Rate Distortion curve of baseline profile.

3.2 Main profile

The same sequence of 10 frames is operated with main profile. In this profile first frame is an IDR and then P and B slices are generated alternately for the next frames if hierarchy is not mentioned. Fig 5 shows the bitrate vs. PSNR performance.

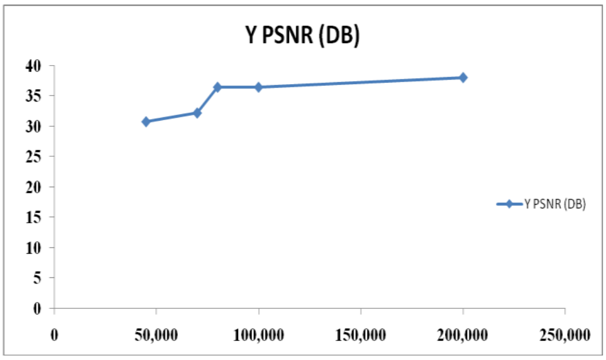

Fig 5: Rate Distortion curve of main profile

3.3 Extended profile

For the extended profile also the observations are almost the same with the same compression. The first frame is encoded as IDR. P and B slices follow alternately for the next frames.

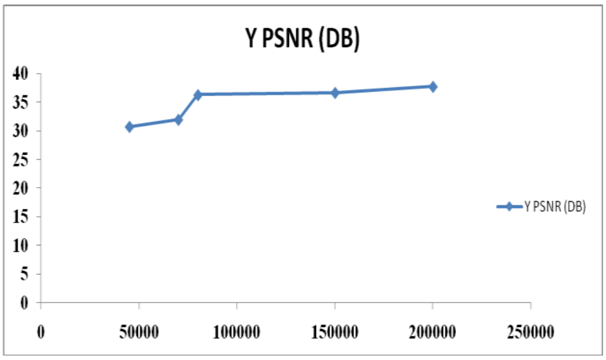

Fig 6: Rate Distortion curve of extended profile

3.4 Comparison

As can be seen from the above figs. 4, 5 and 6, clearly the codec's rate distortion performance shows the tradeoff between PSNR and bitrate, which translates to the fact that higher the bandwidth, better the resulting quality. Coding performance is strongly influenced by the encoder.cfg, configuration file for the encoder. One thing common in all the three profiles is that, there is a sudden increase in slope between bitrates of 70000 and 80000, which is least for baseline profile and highest for extended profile, with main profile's slope in the same range lying between these two, while all other configuration parameters being the same.

4. CONCLUSION

The codec compresses the YUV file with a good degree of compression. The original file of 3 frames is of 112 KB, where as the output binary file has 4 KB size. The binary file displayed in fig 3 can be analyzed by separating the bit stream with a code as 00 00 00 01. The first slot of bytes are of sequence parameter set, the next slot of bytes are picture parameter set and the three slices as the IDR, P, P for baseline profile. YUV file generated by the encoder is the reference file used by the decoder. The stat file in fig. 8 displays the number of frames coded, frequency for the encoded bitstream, image format and many relevant things. One of the desirable properties of a codec includes good rate distortion performance and low processing power required to code the video sequence.

```
@0      SPS: profile_idc                                    01000010 ( 66)
@8      SPS: constrained_set0_flag                                 0 (  0)
@9      SPS: constrained_set1_flag                                 0 (  0)
@10     SPS: constrained_set2_flag                                 0 (  0)
@11     SPS: constrained_set3_flag                                 0 (  0)
@12     SPS: reserved_zero_4bits                                0000 (  0)
@16     SPS: level_idc                                      00101000 ( 40)
@24     SPS: seq_parameter_set_id                                  1 (  0)
@25     SPS: log2_max_frame_num_minus4                             1 (  0)
@26     SPS: pic_order_cnt_type                                    1 (  0)
@27     SPS: log2_max_pic_order_cnt_lsb_minus4                     1 (  0)
@28     SPS: num_ref_frames                                      010 (  1)
@31     SPS: gaps_in_frame_num_value_allowed_flag                  0 (  0)
@32     SPS: pic_width_in_mbs_minus1                         0001011 ( 10)
@39     SPS: pic_height_in_map_units_minus1                  0001001 (  8)
@46     SPS: frame_mbs_only_flag                                   1 (  1)
@47     SPS: direct_8x8_inference_flag                             1 (  1)
@48     SPS: frame_cropping_flag                                   0 (  0)
@49     SPS: vui_parameters_present_flag                           0 (  0)

Annex B NALU w/ long startcode, len 8,
                forbidden_bit       0,
                nal_reference_idc   3,
                nal_unit_type       7
----------------------------------------------------------------------------


@50     PPS: pic_parameter_set_id                                  1 (  0)
@51     PPS: seq_parameter_set_id                                  1 (  0)
@52     PPS: entropy_coding_mode_flag                              0 (  0)
@53     PPS: bottom_field_pic_order_in_frame_present_flag           0 (  0)
@54     PPS: num_slice_groups_minus1                               1 (  0)
@55     PPS: num_ref_idx_l0_default_active_minus1                  1 (  0)
@56     PPS: num_ref_idx_l1_default_active_minus1                  1 (  0)
@57     PPS: weighted_pred_flag                                    0 (  0)
@58     PPS: weighted_bipred_idc                                  00 (  0)
@60     PPS: pic_init_qp_minus26                                   1 (  0)
@61     PPS: pic_init_qs_minus26                                   1 (  0)
@62     PPS: chroma_qp_index_offset                                1 (  0)
@63     PPS: deblocking_filter_control_present_flag                0 (  0)
```

Fig 7: Trace File

```
-------------------------------------------------------------
 This file contains statistics for the last encoded sequence
-------------------------------------------------------------
Sequence                     : foreman_part_qcif.yuv
No.of coded pictures         :     3
Freq. for encoded bitstream  :    30
I Slice Bitrate(kb/s)        : 179.84
P Slice Bitrate(kb/s)        :  95.76
B Slice Bitrate(kb/s)        :   0.00
Total Bitrate(kb/s)          : 276.40
ME Level 0 Metric            : SAD
ME Level 1 Metric            : Hadamard SAD
ME Level 2 Metric            : Hadamard SAD
Mode Decision Metric         : Hadamard SAD
ME for components            : Y
Image format                 : 176x144
Error robustness             : Off
Search range                 : 32
Total number of references   : 1
References for P slices      : 1
Profile/Level IDC            : (66,40)
Entropy coding method        : CAVLC
Search range restrictions    : none
RD-optimized mode decision   : used

---------------------|----------------|---------------|
     Item            |     Intra      |  All frames   |
---------------------|----------------|---------------|
SNR Y(dB)            | 35.90          | 35.61         |
SNR U/V (dB)         | 40.69/42.48    | 40.56/42.36   |
---------------------|----------------|---------------|

---------------------|----------------|---------------|---------------|
     SNR             |        I       |       P       |       B       |
---------------------|----------------|---------------|---------------|
SNR Y(dB)            |     35.903     |     35.456    |     0.000     |
SNR U(dB)            |     40.685     |     40.497    |     0.000     |
SNR V(dB)            |     42.482     |     42.301    |     0.000     |
---------------------|----------------|---------------|---------------|

---------------------|----------------|---------------|---------------|
   Ave Quant         |        I       |       P       |       B       |
---------------------|----------------|---------------|---------------|
      QP             |     30.000     |     30.000    |     0.000     |
---------------------|----------------|---------------|---------------|
```

Fig 8: Stat File

5. REFERENCES

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