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Motion Compensation Techniques Adopted In HEVC

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Abstract: High Efficiency Video Coding (HEVC) is currently being prepared as the newest video coding standard of the ITU-T Video Coding Experts Group and the ISO/IEC Moving Picture Experts Group. The main goal of the HEVC standardization effort is to enable significantly improved compression performance relative to existing standards—in the range of 50% bit-rate reduction for equal perceptual video quality. This paper provides an overview of the technical features and characteristics of the HEVC standard.
Keywords: High efficiency video coding (HEVC), Advanced video coding (AVC), Intra-frame prediction, Merge, Advanced motion vector prediction (AMVP).

I. INTRODUCTION

High Efficiency Video Coding (HEVC) standard is the most recent joint video project of the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG) standardization organizations, working together in a partnership known as the Joint Collaborative Team on Video Coding (JCT-VC). Video coding standards have evolved primarily through the development of the well-known ITU-T and ISO/IEC standards. The ITU-T produced H.261 and H.263, ISO/IEC produced MPEG-1 and MPEG-4 Visual and the two organizations jointly produced the H.262/MPEG-2 Video and H.264/MPEG-4 Advanced Video Coding (AVC) standards. The two standards that were jointly produced have had particularly strong impact and have found their way into a wide variety of products that are increasingly prevalent in our daily lives. Throughout this evolution, continued efforts have been made to maximize compression capability and improve other characteristics such as data loss robustness, while considering the computational resources that were practical for use in products at the time of anticipated deployment of each standard. The major video coding standard directly preceding the HEVC project was H.264/MPEG-4 AVC, which was initially developed in the period between 1999 and 2003, and then was extended in several important ways from 2003–2009. H.264/MPEG-4 AVC has been an enabling technology for digital video in almost every area that was not previously covered by H.262/MPEG-2 Video and has substantially displaced the older standard within its existing application domains. It is widely used for many applications, including broadcast of high definition (HD) TV signals over satellite, cable, and terrestrial transmission systems, video content acquisition and editing systems, camcorders, security applications, Internet and mobile network video, Blu-ray Discs, and real-time conversational applications such as video chat, video conferencing, and tele-presence systems. However, an increasing diversity of services, the growing popularity of HD video, and the emergence of beyond HD formats (e.g., 4k×2k or 8k×4k resolution) are creating even stronger needs for coding efficiency superior to H.264/MPEG-4 AVC's capabilities. The need is even stronger when higher resolution is accompanied by stereo or multi-view capture and display. Moreover, the traffic caused by video applications targeting mobile devices and tablet PCs, as well as the transmission needs for video-on demand services, are imposing severe challenges on today's networks. An increased desire for higher quality and resolutions is also arising in mobile applications.

HEVC has been designed to address essentially all existing applications of H.264/MPEG-4 AVC and to particularly focus on two key issues: increased video resolution and increased use of parallel processing architectures. The syntax of HEVC is generic and should also be generally suited for other applications that are not specifically mentioned above. As has been the case for all past ITU-T and ISO/IEC video coding standards, in HEVC only the bit-stream structure and syntax is standardized, as well as constraints on the bit-stream and its mapping for the generation of decoded pictures. The mapping is given by defining the semantic meaning of syntax elements and a decoding process such that every decoder conforming to the standard will produce the same output when given a bit-stream that conforms to the constraints of the standard. However, it provides no guarantees of end-to end reproduction quality, as it allows even crude encoding techniques to be considered conforming.

II. HEVC DESIGN

The HEVC standard is designed to achieve multiple goals, including coding efficiency, ease of transport system integration and data loss resilience. The following subsections briefly describe the key elements of the design by which these goals are achieved, and the typical encoder operation that would generate a valid bit-stream. The video coding layer of HEVC employs the same hybrid approach (inter-/intra-picture prediction and 2-D transform coding) used in all video compression standards since H.261. Fig. 1 depicts the block diagram of a hybrid video encoder, which could create a bit-stream conforming to the HEVC standard. An encoding algorithm producing an HEVC compliant bit-stream would typically proceed as follows. Each picture is split into block-shaped regions, with the exact block partitioning being conveyed to the decoder. The first picture of a video sequence (and the first picture at each clean random access point into a video sequence) is coded using only intra-picture prediction (that uses some prediction of data spatially from region-to-region within the same picture, but has no dependence on other pictures). For all remaining pictures of a sequence or between random access points, inter-picture temporally predictive coding modes are typically used for most blocks. The encoding process for inter-picture prediction consists of choosing motion data comprising the selected reference picture and motion vector (MV) to be applied for predicting the samples of each block. The encoder and decoder generate identical inter-picture prediction signals by applying motion compensation (MC) using the MV and mode decision data, which are transmitted as side information.
The residual signal of the intra- or inter-picture prediction, which is the difference between the original block and its prediction, is transformed by a linear spatial transform. The transform coefficients are then scaled, quantized, entropy coded, and transmitted together with the prediction information. The encoder duplicates the decoder processing loop (see gray-shaded boxes in Fig. 1) such that both will generate identical predictions for subsequent data. Therefore, the quantized transform coefficients are constructed by inverse scaling and are then inverse transformed to duplicate the decoded approximation of the residual signal. The residual is then added to the prediction, and the result of that addition may then be fed into one or two loop filters to smooth out artifacts induced by block-wise processing and quantization. The final picture representation (that is a duplicate of the output of the decoder) is stored in a decoded picture buffer to be used for the prediction of subsequent pictures. In general, the order of encoding or decoding processing of pictures often differs from the order in which they arrive from the source; necessitating a distinction between the decoding order (i.e., bitstream order) and the output order (i.e., display order) for a decoder. Video material to be encoded by HEVC is generally expected to be input as progressive scan imagery (either due to the source video originating in that format or resulting from deinterlacing prior to encoding). No explicit coding features are present in the HEVC design to support the use of interlaced scanning, as interlaced scanning is no longer used for displays and is becoming substantially less common for distribution. However, a metadata syntax has been provided in HEVC to allow an encoder to indicate that interlace-scanned video has been sent by coding each field (i.e., the even or odd numbered lines of each video frame) of interlaced video as a separate picture or that it has been sent by coding each interlaced frame as an HEVC coded picture. This provides an efficient method of coding interlaced video without burdening decoders with a need to support a special decoding process for it. In the following, the various features involved in hybrid video coding using HEVC are highlighted as follows.

1) *Coding tree units and coding tree block (CTB) structure:* The core of the coding layer in previous standards was the macro-block, containing a 16×16 block of luma samples and, in the usual case of 4:2:0 color sampling, two corresponding 8×8 blocks of chroma samples; whereas the analogous structure in HEVC is the coding tree unit (CTU), which has a size selected by the encoder and can be larger than a traditional macro-block. The CTU consists of a luma CTB and the corresponding chroma CTBs and syntax elements. The size L×Lof a luma CTB can be chosen as L= 16, 32, or 64 samples, with the larger sizes typically enabling better compression. HEVC then supports a partitioning of the CTBs into smaller blocks using a tree structure and quadtree-like signaling.
2) *Coding units (CUs) and coding blocks (CBs):* The qudtree syntax of the CTU specifies the size and positions of its luma and chroma CBs.The root of the quadtree is associated with the CTU.

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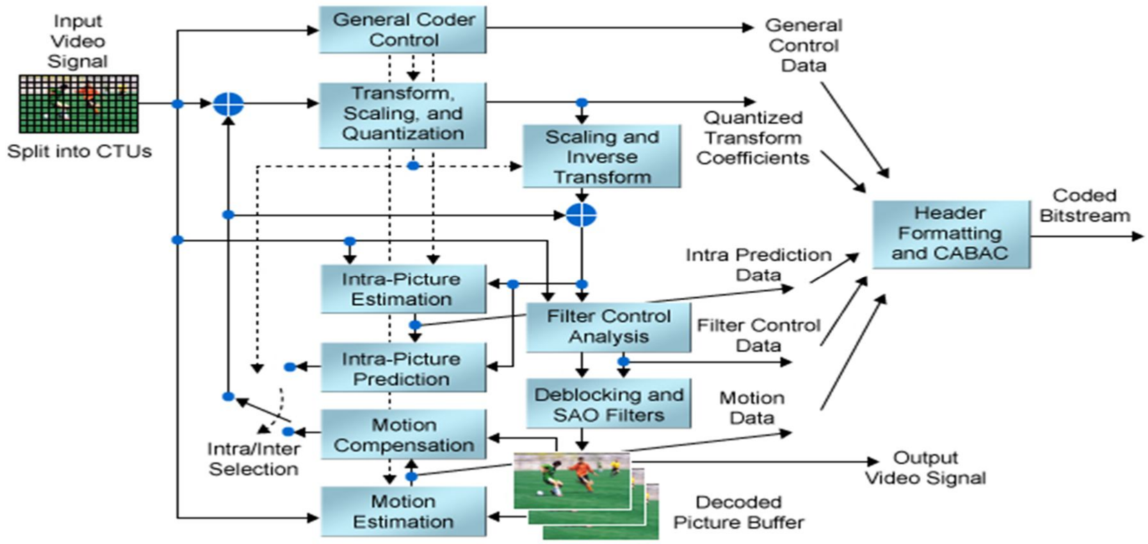

Fig 1: block diagram of HEVC

Hence, the size of the luma CTB is the largest supported size for a luma CB. The splitting of a CTU into luma and chroma CBs is signaled jointly. One luma CB and ordinarily two chroma CBs, together with associated syntax, form acoding unit (CU). A CTB may contain only one CU or may be split to form multiple CUs, and each CU has an associated partitioning into prediction units (PUs) and a tree of transform units (TUs).

3) *Prediction units and prediction blocks (PBs):* The decision whether to code a picture area using interpicture or intrapicture prediction is made at the CU level. A PU partitioning structure has its root at the CU level. Depending on the basic prediction-type decision, the luma and chroma CBs can then be further split in size and predicted from luma and chroma prediction blocks (PBs). HEVC supports variable PB sizes from 64×64 down to 4×4 samples.
4) *TUs and transform blocks:* The prediction residual is coded using block transforms. A TU tree structure has its root at the CU level. The luma CB residual may be identical to the luma transform block (TB) or may be further split into smaller luma TBs. The same applies to the chroma TBs. Integer basis functions similar to those of a discrete cosine transform (DCT) are defined for the square TB sizes 4×4, 8×8, 16×16, and 32×32. For the 4×4 transform of luma intra-picture prediction residuals, an integer transform derived from a form of discrete sine transform (DST) is alternatively specified.
5) *Motion vector signaling:* Advanced motion vector prediction (AMVP) is used, including derivation of several most probable candidates based on data from adjacent PBs and the reference picture. A merge mode for MV coding can also be used, allowing the inheritance of MVs from temporally or spatially neighboring PBs. Moreover, compared to H.264/MPEG-4 AVC, improved skipped and direct motion inferences are also specified.
6) *Motion compensation*: Merge concept is adopted in HEVC . which means merging or combining of motion vector candidates of similar image contents into one motion vector .Quarter-sample precision is used for the MVs, and 7-tap or 8-tap filters are used for interpolation of fractional-sample positions (compared to six-tap filtering of half-sample positions followed by linear interpolation for quarter-sample positions in H.264/MPEG-4 AVC). Similar to H.264/MPEG-4 AVC, multiple reference pictures are used. For each PB, either one or two motion vectors can be transmitted, resulting either in uni-predictive or bi-predictive coding, respectively. As in H.264/MPEG-4 AVC, a scaling and offset operation may be applied to the prediction signal(s) in a manner known as weighted prediction.
7) *Intra-picture prediction*: The decoded boundary samples of adjacent blocks are used as reference data for spatial prediction in regions where inter-picture prediction is not performed. Intra-picture prediction supports 33 directional modes (compared to eight such modes in H.264/MPEG-4 AVC), plus planar (surface fitting) and DC (flat) prediction modes. The selected intra-picture prediction modes are encoded by deriving most probable modes (e.g., prediction directions) based on those of previously decoded neighboring PBs.
8) *Quantization control:* As in H.264/MPEG-4 AVC, uniform reconstruction quantization (URQ) is used in HEVC, with

quantization scaling matrices supported for the various transform block sizes.

9) *Entropy coding:* Context adaptive binary arithmetic coding (CABAC) is used for entropy coding. This is similar to the CABAC scheme in H.264/MPEG-4 AVC, but has undergone several improvements to improve its throughput speed (especially for parallel-processing architectures) and its compression performance, and to reduce its context memory requirements.

10) *In-loop deblocking filtering*: A deblocking filter similar to the one used in H.264/MPEG-4 AVC is operated within the inter-picture prediction loop. However, the design is simplified in regard to its decision-making and filtering processes, and is made more friendly to parallel processing.

11) *Sample adaptive offset (SAO):* A nonlinear amplitude mapping is introduced within the inter-picture prediction loop after the deblocking filter. Its goal is to better reconstruct the original signal amplitudes by using a look-up table that is described by a few additional parameters that can be determined by histogram analysis at the encoder side. A new video coding tool, sample adaptive offset (SAO), is introduced in this paper. SAO has been adopted into the Working Draft of the new video coding standard, High-Efficiency Video Coding (HEVC). The SAO is located after deblocking in the video coding loop. The concept of SAO is to classify reconstructed pixels into different categories and then reduce the distortion by simply adding an offset for each category of pixels.

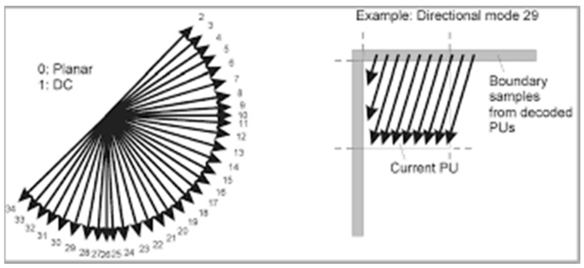

Fig 2: intra-prediction in HEVC

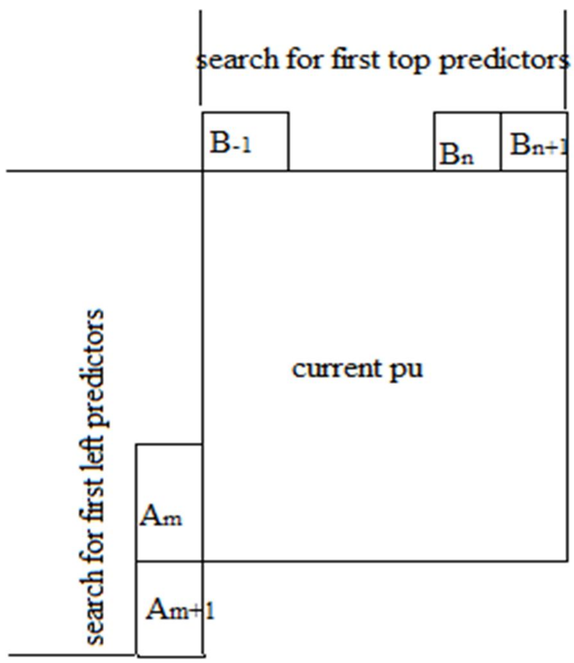

Fig 3: amvp mode of prediction

III. SIMULATION RESULTS

In this paper the simulation results are comparing with advanced video coding standard. In the HEVC video coding standards two types of motion compensation techniques are adopted. Which are merge and advanced motion vector prediction. The below figures shows that the HEVC coding is very much efficient in the video coding. The residul video means it is the difference between the original video and the video is getting after applying the motion vector to the original videoor input video. For compression we need to the residual signal instead of the original signal. In the advanced video coding the size of the residual video signal is high as compared to high efficiency video coding. The below figures are the original video frame, residual video frame of advanced video coding, residual video frame of the high efficiency video coding and the reconstructed video frame after the completion of high efficiency video coding.

Fig 4: input video signal frame

Fig 5: residual video frame of advanced video coding

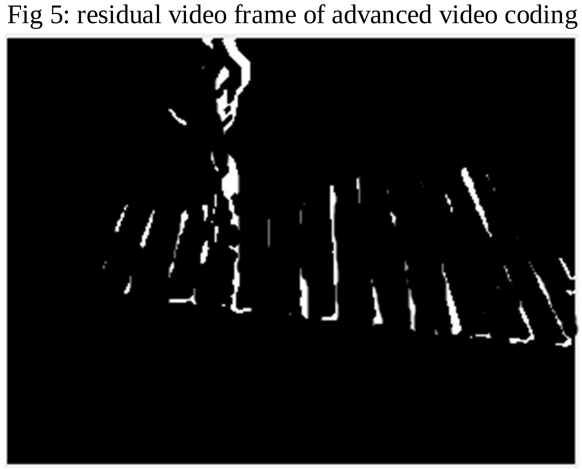

Fig 6: residual video frame of HEVC

Fig 7: reconstructed video frame

IV. CONCLUSION

The emerging HEVC standard has been developed and standardized collaboratively by both the ITU-T VCEG and ISO/IEC MPEG organizations. HEVC represents a number of advances in video coding technology. Its video coding layer design is based on conventional block-based motion compensated hybrid video coding concepts, but with some important differences relative to prior standards When used well together, the features of the new design provide approximately a 40% bit-rate savings for equivalent perceptual quality relative to the performance of prior standards (especially for a high-resolution video). For more details on compression performance. Implementation complexity analysis is outside the scope of this paper; however, the decoder implementation complexity of HEVC overall is not a major burden (e.g., relative to H.264/MPEG-4 AVC) using modern processing technology, and encoder complexity is also manageable.

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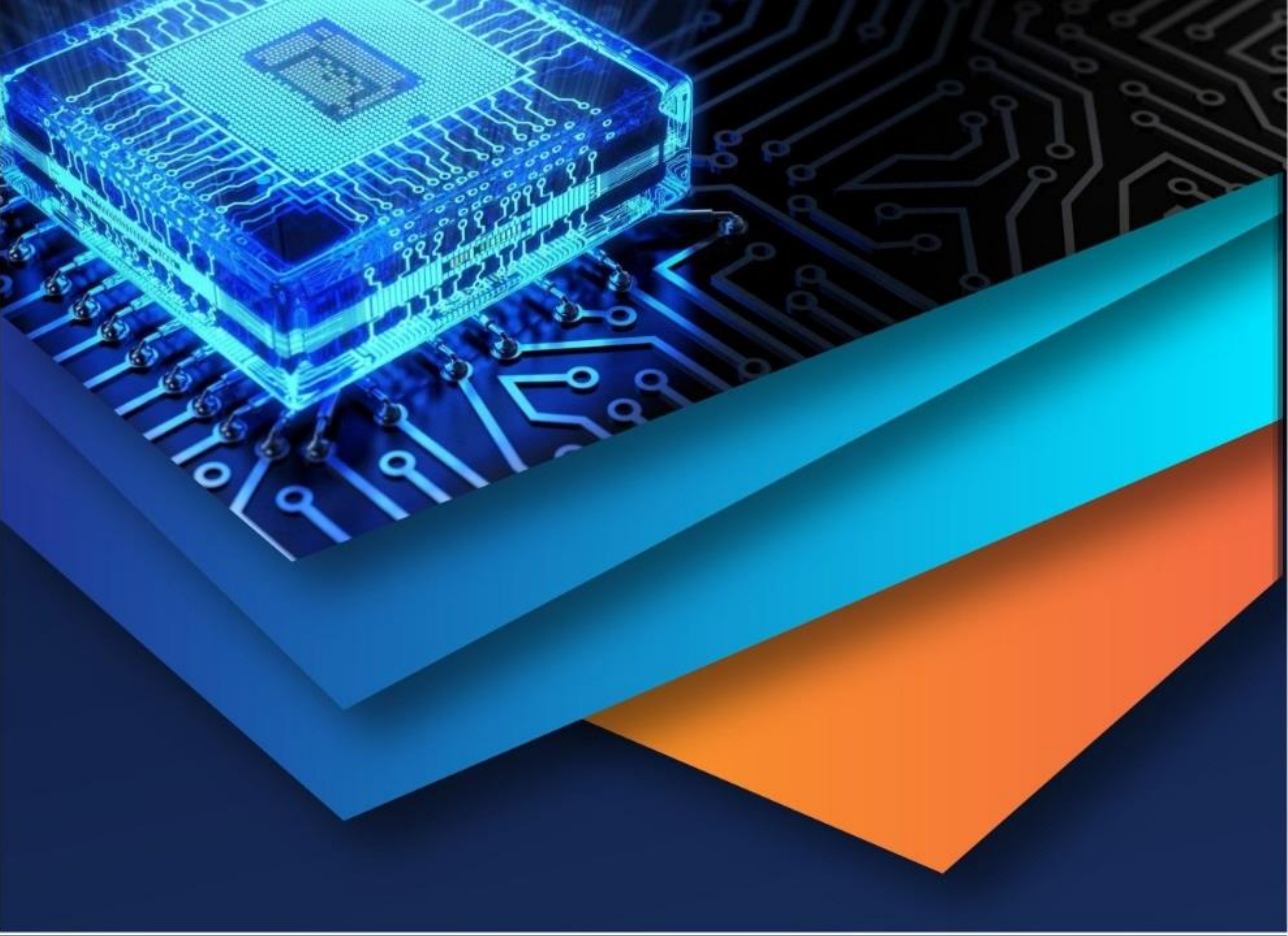

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