Comparative Review on Error Resilient Multiple Description Coding Methods on H.264/MPEG-4 Part 10

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Abstract- *H.264 or MPEG-4 Part 10, Advanced Video Coding (MPEG-4 AVC) is a video coding(block-oriented motion-compensation-based video compression standard) which is used for the recording, compression, and distribution of video content. Moving Picture Expert Group-4 (MPEG-4) is an ISO/IEC video coding standard which supports highly interactive multimedia applications as well as traditional applications. It includes many advanced functionalities such as interactivities, scalabilities and Error resilience. Multiple description coding is source coding in which several descriptions of the source are produced such that various reconstruction qualities are obtained from different subsets of the descriptions. Multiple description coding (MDC) is an effective Error resilience technique for video coding. In case of frame loss, error concealment (EC) techniques can be used in MDC to reconstruct the lost frame, with error, from which subsequent frames can be decoded directly. This paper investigates the effect of Error resilient coding (ERC) on H.264/MPEG-4 Part 10 or AVC (Advanced Video Coding) and multiple description coding (MDC). We also propose a Algorithm for Error concealment (EC) to improve the error recovery rate of any EC in the temporal subsampling MDC. Both subjective and objective results show that there is significant improvement in video quality than direct decoding.*

Keywords- Scalability, Error concealment, multiple description coding, Error resilience.

I. INTRODUCTION

To enable the compressed bit-stream to better resist channel errors or Error resilience technique enable the compressed bit-stream to resist channel errors so that the impact on the reconstructed image quality is minimal.

Some part of the information is inevitably lost and the goal of error concealment [10], at the receiving side ,is to estimate the losses and conceal them in the displayed video.

Error resilience takes nearly 20% of the consumption. Error Resiliency is inversely proportional to compression. Because, generally the Error Resilience schemes introduce some redundancy in the data. On the other hand compression schemes aim to remove various redundancies from the data.

In H.264 we can find several parameters that can be tuned so that a trade- off between compression rate and Error Resiliency can be made targeting different type of problems found in heterogeneous environments.

II. ERROR RESILIENCY SCHEME

The H.264/AVC video coding standard explicitly defines all the syntax elements, such as motion vectors, block coefficients, picture numbers, and the order they appear in the video bitstream. Syntax actually is the most important tool for ensuring compliance and error detection. Like other video coding standards, H.264/AVC [1] only defines the syntax of the decoder in order to allow flexibility in specific implementations at the encoder.

However "it provides no guarantees of end-to-end repro- duction quality, as it allows even crude encoding techniques to be considered conforming" [2]. Basically a video bitstream corrupted by error(s) will incur syntax/semantics error(s). Due to the use of VLC, errors often propagate in the bitstream until they are detected. The syntax/semantics errors may include [3]

i) Illegal value of syntax elements.
ii) Illegal sync header.
iii) More than 16 coefficients are decoded in a 4x4 block.
iv) An incorrect number of stuffing bits are found.
This could also occur when extra bits remain after Deco-ding all expected coefficients of the last coded block in a video packet.
v) Some of the coded blocks in a video packet cannot be decoded.

We have the following error resiliency scheme;

1) Flexible Macroblock Ordering (FMO)
2) Intra-Block refreshing by Rate Distortion (R-D) Control
3) Arbitrary Slice Ordering (ASO)
4) Redundant Slices
5) Data Partitioning

Mainly in this paper we are concern with Flexible Macroblock Ordering (FMO) and Intra-Block refreshing by Rate Distortion (R-D) Control

Flexible Macroblock Ordering (FMO):

It randomizes the data prior to transmission ,so that if a segment of data is lost (eg. A packet or several packets), the errors are distributed more randomly over the video pictures ,rather than causing corruption of a complete regions ,making it more likely that relevant neighboring data is available concealment of lost content.

To, Achieve this, each MB is statically assigned to a slice group using Macroblock Allocation Map (MBA). MBA map in H.264 supports following arbitrary shapes;

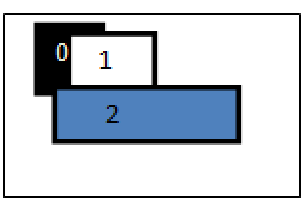
1. Interleaved

0
1
2
0
1
2
0
1
2

2. Dispersed

0	1	2	3	0	1	2
2	3	0	1	2	3	0
0	1	2	3	0	1	2
2	3	0	1	2	3	0
0	1	2	3	0	1	2
2	3	0	1	2	3	0

3. Foreground and Background



Intra-Block refreshing by Rate Distortion (R-D) Control

The error propagation and drift due to predictive coding can be eliminated by periodically inserting intra-coded MBs in the bit-stream.

Error Propagation

A transmission error such as a bit error or packet loss may cause a video decoder to lose synchronization with the sequence of decoded Variable Length Coding (VLCs).

This can cause the decoder to decode incorrectly some or all of the information after the occurrence of the error and this means that part or all of the decoded video object plane(VOP) will be distorted or completely ,lost(ie. the effect of the error spreads Spatially through the video object plane, Spatial error propagation[6].

If subsequent VOPs are predicted from the damaged VOP, the distorted are a may be used as predicted reference, leading to Temporal error propagation in subsequent VOPs.

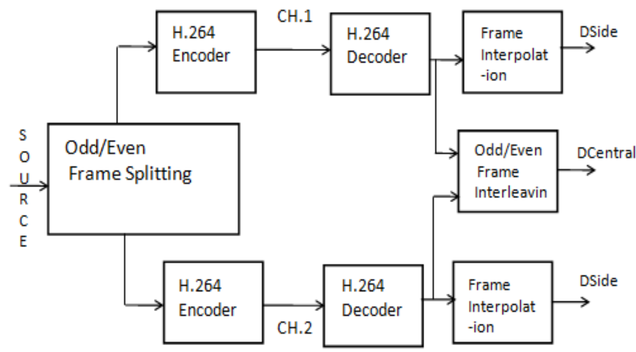


Figure-1: Block Diagram of Temporal Domain MDC

III. MDC BASICS

Multiple Description Coding was originally used for speech communicating over circuit-switched network in the 1970's. Traditionally, to avoid communication interruption, an additional transmission link was on standby and would be activated in the case of the outage of the main link. This approach however was not cost efficient and therefore the idea of splitting the information over two channels; i.e. MDC, was proposed. At the 1979 IEEE Information Theory Workshop, the MD problem was posed by Gersho, Witsenhausen, Wolf, Wyner, Ziv, and Ozarow. Suppose a source is described by two descriptions each decoded at rate R1 and R2. Each description can be individually decodable with distortion D1 and D2,respectively, while decoding the two descriptions together leads to distortion D0; the MD problem is to characterize the achievable quintuples[D0, D1,D2,R1,R2] .

Fig. 2 shows the basic block diagram of MDC. This figure shows a two-description case but a higher number of descriptions is possible. In the figure, a source is coded such that multiple complementary descriptions that are individually decodable are generated. After the descriptions are built, they can be transmitted separately, possibly through different network paths. At the receiver side, if only one description is available, it is decoded by the side decoder and the resulting quality (distortion) is called side quality (distortion). When both descriptions are available, they are decoded by the central decoder and the resulting quality (distortion) is called central distortion (quality).

In central decoder the descriptions are merged and hence a video with higher quality is achieved[9]. In other words, there exist two types of decoding at the receiver, when all descriptions are received the central decoding is used, and if one or more descriptions are not received the side decoder is used for the received description(s)[5]. Obviously, quality is enhanced by the number of received descriptions.

Since predictive coding is used in all modern video codecs, the quality of a predicted frame will depend on its reference frame. When MDC's side decoder is active; i.e., when some descriptions are lost,a reference frame may not be reconstructed correctly due to this loss, leading to noisy reconstruction of all other frames which are predicted from it. Subsequently, some of the erroneous frames could in turn be used as reference for other frames and so error propagation occurs.

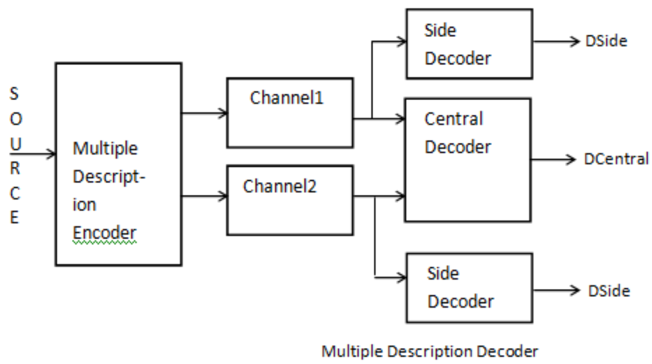


Figure 2: Block diagram of MDC

IV. ERC OPTIONS OF H.264/AVC VERSUS MDC

These options work only if the loss rate is very low or at most low. In moderate or high loss rate environments, MDC is more beneficial[4].

H.264 uses intelligent intra-block refereshing by R-D control, such that an apporopriate block coding option o* will be selected that minimizes the "Lagrangian Cost Fuction" ,unlike the periodic or random intra refresh in earlier standards (eg. MPEG-4,H.263).

$$O^* = \arg\min_{o \in X} \left[D(o) + \lambda R(o) \right]$$

Here O =Block coding mode (Inter/Intra mode and block size)

$D(o)$ =Distortion introduces by encoding with mode O and is computed by the Sum of Absolute Difference (SAD) in low complexity mode and by Sum of Squared Difference (SSD) in high complexity mode

λ =Lagrange parameter for appropriate weighting of rate and distortion

$R(o)$ = Corresponding coding rate, whereas for Inter-block mode it represents the block residual and corresponding motion vector(s).

Error Concealment Application Programming Interface (API)

Intra-Block refreshing by Rate Distortion (R-D) Control
Double RD cost_for_8X8 blocks

```
(
        int* cnt_nonz ,    //--> number of nonzero cofficients
        int 64* cbp_blk,           //--> cbp_blk
        double lambda,            //<-- Lagrange multiplier
         int block,               //<-- 8 X 8 block number
         int mode,                //<-- partitioning mode
        short pdir,               //<-- prediction direction
        short ref,                //<-- reference frame
         short bwd_ref,           //<-- abp type
 )
```

Desc- Calculates cost function to find the appropriate block coding option.
Return- Get Rate –Distortion Cost

Detail of Sequence Used;
Name - Foreman
Size - QCIF (176x144)
Frame rate - 7.5 fps
Bit rate - 64 Kbps
No. of frames -100

Figure 3: Snapshot of "foreman" video sequence

V.CONCLUSION

Based on the descriptions and criteria, the MDCs and their functionalities are given as-

1. Using Duplicating the motion information in both descriptions (MDC Approach) [7-8] below mentioned results are observed:
   a. Standard compatibility - No
   b. Redundancy tunability - Moderate

c. Complexity – Low

Summary – Motion Vectors (MVs) help to conceal the lost description more efficiently, with the cost of additional rate for sending MVs.

2. Using Multi-rate MDC(MDC approach) [9-10] below mentioned results are observed:

   a. Standard compatibility - Yes
   b. Redundancy tunability - High
   c. Complexity - Moderate

Summary – A coarser quantized version of the frames of description 1 (2) are copied into description 2 (1).

In this paper, we described various error resiliency schemes, including a few no normative error concealment schemes, employed by H.264/AVC. We observe that for video transmission over channels with moderate to high and fluctuating loss rate, MDC is a good solution due to the redundancy inherent in MDC streams.

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