A STUDY ON VIDEO COMPRESSION IN WIRELESS SENSOR NETWORK AND PERCEPTUALLY DRIVEN ERROR PROTECTION

J.Kasthuri,
M.Phil Scholar,
PG & Research Department of Computer Science,
Sengunthar Arts and Science College,
Tiruchengode,Tamilnadu,India.

R.Bharathi,
Assistant Professor,
PG & Research Department of Computer Science,
Sengunthar Arts and Science College,
Tiruchengode,Tamilnadu,India.

Abstract: With the constantly increasing number of new electronic devices capable of capturing, editing, storing and sharing video content all over the world, the volume of video data being transmitted in today's communication networks is significantly growing. In typical video transmission systems, video signals are compressed and sent to the decoder through an error-prone communication channel that may corrupt the compressed video signal, causing the degradation of the final decoded video quality. This paper studied about Perceptually Driven Error Protection (PDEP) video codec provides a good alternative to traditional error protection video coding schemes, notably FEC-based schemes, even when the perceptual aspects of the video content are not considered.

Keywords: Wireless Sensor Network, Perceptually Driven Error Protection, Video Compression, Multimedia Streams

I.INTRODUCTION

WSN is a promising technology for distributed sensing and computation. Although constrained by limited computational capabilities, sensor networks are cost-effective and have good scaling virtues. The use of a low-power radio communication protocol such as the IEEE 802.15.4 allows eliminating the cost of cabling the sensors, and allows more flexibility in the deployment. So far, WSNs have been mainly used in applications with low frequency sampling and little computational complexity, such as environmental monitoring in agriculture, monitoring and control of the temperature and light in home automation, etc. Recently, researchers and engineers started to investigate the use of WSNs to support more demanding applications, including process control, industrial automation, video surveillance, and multimedia streaming. Some early attempts have been made to use WSN technology for low-quality video streaming. The success of such attempts has created a new challenging area of research, MWSN. MWSN technology is a good candidate for use in pervasive contexts like info-mobility. The idea is to use a set of inexpensive sensors nodes equipped with low-cost cameras in city streets to monitor traffic flows, number of cars in parking lots, etc.. The information are collected by the sensors and sent through wireless communication to a concentrator node that aggregates the incoming data (sensor fusion). The concentrator, which is in charge of collecting data related to a specific city area, is then connected to a wide area network, and sends aggregated data to higher levels of the information system hierarchy, which monitor and control urban mobility [1]. The architecture of such a system is shown in Figure 1. The backbone network can be wired (e.g. ADSL or Ethernet) or wireless (e.g. WiFi, WiMax, GPRS or UMTS), depending on the specific needs. In this proposal, we are interested in the lower level of the hierarchy that includes the sensor nodes and the concentrator [2].
Examples of applications are:

- Counting the number of cars passing on city streets. This information can help in estimating the traffic flow entering in (or exiting from) a city area, and take appropriate actions to prevent congestion. While there are other methods to count the number of cars passing in a street (by magnetic sensors, photoelectric cells, etc.), we envision that the one based on WSN cameras will be more flexible, easier to install and more cost-effective.
- Identifying the occupancy level of a parking lot in a open area. This information can help to provide appropriate advices to drivers and guide them to the free spots. Also in this case there are many working examples of parking lots equipped with sensor systems. However, these systems are more difficult to be installed in open environments, due to high cabling cost. The use of WSN will help to lower the cost of installation and maintenance.

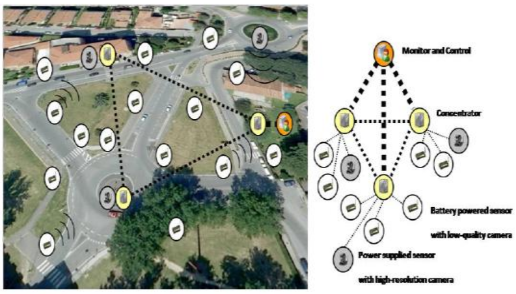

Figure 1: An illustrative example of a MWSN architecture.

- Counting number of people entering a building or in a room, or detect intrusion into limited access areas. Such information can be exploited for marketing purposes (e.g. how many people pass by a corridor) or scheduling personnel (i.e. how many employees are needed at a particular time of the day). A typical solution is an embedded unit with a single counter and camera integrated. The use of WSN could increase the system robustness, especially in challenging scenarios where the error rate goes up to 30

- Counting people outdoor is a state-of-the-art challenge and no product is doing that reliably these days. The information is useful for public authorities (e.g. townhall, police) that are interested in to distributing police agents and schedule their personnel. The use of WSN in outdoor counting will help lower main technical problems associated to this scenario, like harsh illumination conditions, weather, occlusions due to crowds, etc.
- Monitoring industrial processes. Video cameras are being used in industrial processes to identify defects in products, or to monitor a hazardous area. Using less expensive wireless cameras would simplify these tasks and allow more cameras to be installed with less effort and inferior cost with respect to current monitoring systems. Also, a real-time architecture for WSN would allow controlling the manufacturing process, and de-localizing control algorithms, to make them closer to the sensors, thus reducing the overall cost. Such applications can be denoted as Visual Monitoring (VM) applications, since they are characterized by the use of vision to monitor some environmental data of interest.

Video Standards: Basically there are two families of standards:

- ISO/IEC (International Standards Organization and International Electro- Technical Commission)
- ITU (International Telecommunications Union)

ISO/ IEC produced the MPEG standards which are the standard formats for video compression. ITU-T developed several recommendations for video coding such as H.261,

Fundamentals of Lossy Compression: Lossy compression is applied usually to the video to obtain good results for compression. The name itself implies that the compressed video loses some information from the original one but also its size is reduced to a great extent. Though the quality of the compressed video is lower than that of the original video, the size of the compressed video is much lesser than the size of the original video. Lossless compression is the compression type in which the compressed file is used and the original file can be reconstructed exactly as before.

Representation of colours: For displaying a perfect colour picture, three primary colours (red, green, blue) are basically needed. Because of this, every pixel contains minimum three different information channels. RGB and YUV are the generally used representation methods for colours. RGB includes the three primary colours along with the information about brightness. Generally the displays are monitored using this RGB representation. The colour space is divided into chrominance (colour) and luminance (brightness) in the YUV representation. Human beings are less sensitive to colour than to brightness. Hence the chrominance information can be suppressed than the brightness information such that most of the quality is not lost. YUV data also helps in deriving the 3 basic colours (red, green, blue). In video compression, as the YUV representation produces better compression results, this representation is extensively used than the RGB representation.

II.VIDEO COMPRESSION TECHNIQUES

There is several video compression techniques developed in the last two decades. However the DCT compression and the wavelet compression are used much extensively. In video compression, the video is converted into individual frames and then compression techniques are applied on the images to compress the given file [3]. The compressed images are decompressed and again a video could be created from those so that the compressed video is obtained. In the DCT method, the image is divided into small blocks and then the DCT is applied on each block. Applying DCT converts every pixel value into the frequency domain. DCT converts the pixel values into the frequency domain in such a way that the low frequencies are on the top-left and higher frequencies are on the bottom right. Then quantization is done so that the DCT coefficients become integers as they have been scaled by a scaling factor. By applying inverse discrete cosine transform (IDCT), original images can be reconstructed but not 100% similar to the actual ones. In wavelet compression, the compression techniques are applied on the image as a whole (i.e., image need not be divided into smaller blocks). The aim of this compression technique is to store the image data in as little space as possible. The standard formats for video compression such as the MPEG methods and the recommended methods such as H.261, H.263 are also used widely. MPEG standards are again developed periodically to meet the required demands with the progress of time such as MPEG-1, MPEG-2, MPEG-4, MPEG-7, etc[4][5][6].

JPEG: JPEG is an acronym for Joint Photographic Experts Group. It is one of the compression techniques used for still image compression. It typically achieves a compression ratio of 10 upto acceptable loss of quality and as known already, there will be a tradeoff between the compression ratio and the quality. Generally most of the digital cameras save images in this format. For paintings on realities and for photography, JPEG is the best technique. JPEG is a type of lossy compression and it uses DCT approach to achieve the compression.

Motion JPEG : This is nothing but a series of still JPEG pictures. But the disadvantage is that it uses image compression techniques on the moving JPEG frames but no video compression technique has been used here. But it is also an advantage that if a single frame is lost during transmission, still the video will not be affected.

JPEG 2000: This was developed after JPEG. Instead of the DCT approach used in the JPEG for compression, wavelet transformation is used in the JPEG 2000 and this technique achieves better compression ratios. The main advantage of this technique over the JPEG is that the blockiness observed in the JPEG is removed and replaced by an overall fuzzy image.

Motion JPEG 2000: This is also used to compress a video file. It has the similar advantages compared to the JPEG but with the tradeoff between complexity and the compression ratios, a better compression ratio can be achieved in this technique. This technique has the same drawback as that of the motion JPEG that it is just an image compression technique for individual frames but it does not perform any video compression techniques. This may result in the lower compression ratios compared to the real video compression schemes. As a video compression technique, motion JPEG 2000 has never been a success.

H.261/ H.263: These are not the international standards but the recommendations by the ITU. They can be considered as the simplified versions of the MPEG techniques. Since they were actually developed for low bandwidth i.e., for applications like video conferencing; they cannot provide the efficient usage of the bandwidth as some of the most advanced MPEG techniques are not included in these techniques. Hence it can be conclude that H.261 and H.263 are generally not used for video compression.

MPEG-1: This was the basic compression standard developed by the ISO/IEC family in the year 1993. The idea is to store the video files in a format suited to CDROMs. Using this standard, video is encoded at a data rate of less than 1.4 Mbps. This standard introduced the mp3 audio format which is the most popular today.

MPEG-2: This is an extended version of MPEG-1 which uses higher bandwidth to achieve higher quality and to cover bigger images. These compression techniques are used for the television and telecommunication standards. These techniques are also used in compressing the DVD movies. Higher resolution and a higher transmission rate of 10 Mbps can be observed in this compression technique.

MPEG-3: This was developed as an extension to MPEG-2 but later it was found that by making small adjustments to the MPEG-2, it performs the operations to be done by MPEG-3 i.e., to handle HDTV. Hence the research on MPEG-3 has not been done widely and now it has been stopped.

MPEG-4: This technique was developed intending to interactive multimedia, video telephony. The transmission of full-motion video at a low bit-rate of only 9-40 kbps is done with this technique. "The classic MPEG-4 video streaming standard is called the MPEG-4 Visual". MPEG-4 has been developed for the transfer of video over the internet and hence it has lower data rate of 64 kbps only.

H.264: The latest standard developed for the video compression is the H.264 standard. It should provide a better video quality at the same bit rate. In this technique as the more applications are possible, all of these have to be implemented without much increase in the complexity of the system. This technique also provides the flexibility to perform a vast range of operations. Some of the important applications to be done using H.264 are:

a) Cable TV, broadcasting, satellite etc.
b) Streaming services
c) Telecom services

Also, the H.264 encodes the HD-DVD and Blu-ray support movies.

MPEG-7: This technique does not involve in the compression of any moving image or audio. This is often used in the video surveillance. Multimedia content description interface is done here. A meta-data for audio-video streams is generated by the MPEG-7. Though this model does not depend on the actual multimedia compression techniques, the MPEG-4 representation can also be suited to the MPEG-7 technique. Some of the applications of MPEG-7 are used in video analytics.

MPEG-21: In the modern days, digital data can be distributed illegally. Hence in order to prevent these kinds of events, this technique has been developed. This defines the ways for sharing the permissions, digital rights, licenses of the digitalized data. In video surveillance applications, MPEG-21 cannot be used.

MPEG Frame Types : A video frame is compressed using different compression algorithms. For video frames, these different algorithms are called picture types or frame types. Basically there are three different frame types used in the different video compression algorithms. They are:
I-frames (don't require other frames and is least compressible**)**
P-frames (uses data from previous frame to decompress**)**
B-frames (uses data both from the previous frame and future frame to decompress**)**

- "**I-frame** means Intra frame in which every block is coded using raw pixel values, so it can always be decoded without additional information".
- **"P-frame** is the name to define the forward Predicted pictures. The prediction is made from an earlier picture, mainly an I-frame, so that require less coding data (≈50% when compared to I-frame size)".
- **"B-frame** is the term for bi-directionally predicted pictures. This kind of prediction method occupies less coding data than P-frames (≈25% when compared to I-frame size) because they can be predicted or interpolated from an earlier and/or later frame".

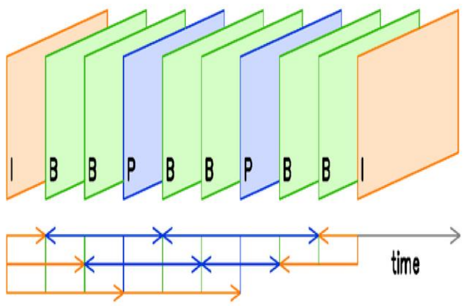

Figure 2: IPB frames inter-sequence

COMPRESSION CONSTRAINTS

- **Quality:** While performing compression operations, the quality of the compressed video should be taken into account and the compressed video should not lose its quality beyond a certain acceptable level.
- **Complexity:** While executing the different algorithms to obtain compression, the complexity of the algorithm is an important factor. It should not be too complex.

- **Delay:** The execution time should be optimum while running a compression algorithm on a given video. While applying complex algorithms, it usually takes time to implement but the delay should not be very large.
- **Compression ratio:** The ratio of the original file size to the compressed file size is called compression ratio. To obtain better compression ratios, the quality of the video has to be forfeited.

The above constraints for the compression are all very essential and according to the need of the user, there will be a tradeoff between these constraints. For example, both the better quality and high compression ratios cannot be achieved together. To achieve one of these, the other can be neglected.

III.REVIEW OF LITERATURE

Wing-Chung Ma, et al. [7] has proposed "A Novel Four-Step Search Algorithm for Fast Block Motion Estimation" in 1995. The proposed algorithm has given based on the center-biased global minimum motion vector distribution characteristic of real world image sequence, a new Four-Step Search algorithm for fast block-based motion estimation. Experimental results show that the proposed Four-Step Search algorithm performs better than the well-known 3SS and have similar performance to the N3SS in terms of mean-square error measure with smaller computational requirement. In addition, Four-Step Search is more robust as compared with 3SS and N3SS. It is because the performance of Four-Step Search is maintained for image sequence that contains complex movement such as camera zooming and fast motion. On the other hand, the Four-Step Search also possesses the regularity and simplicity of hardware oriented features.

Yih-Chuan Lin, et al. [8] has proposed a technique "Fast Full-Search Block- Matching Algorithm for Motion-Compensated Video Compression" in 1997. The proposed technique has been built upon a fast block-matching algorithm that uses three fast matching error measures, besides the conventional mean-absolute error (MAE) or mean-square error (MSE).An incoming reference block in the current frame is compared to candidate blocks within the search window using multiple matching criteria. These three fast matching error measures are established on the integral projections, having the advantages of being good block features and having simple complexity in measuring matching errors. Most of the candidate blocks can be rejected only by calculating one or more of the three fast matching error measures. The time-consuming computations of MSE or MAE are performed on only a few candidate blocks that first pass all three fast matching criteria. The proposed technique has given simulation results show that a reduction of over 86% in computations is achieved after integrating the three fast matching criteria into the full search algorithm, while ensuring optimal accuracy.

MuzhirShaban Al-Ani, et al. [10] has proposed a "Video Compression Algorithm Based on Frame Difference Approaches" in 2011. The proposed design is implemented Wavelet transform is an efficient method that can be used to perform an efficient compression technique. This work deals with the developing of an efficient video compression approach based on frames difference approaches that concentrated on the calculation of frame near distance (difference between frames). The selection of the meaningful frame depends on many factors such as compression performance, frame details, frame size and near distance between frames. The implemented system passes into many steps; pre-processing, frame extraction, frame selection, frame reordering, 2D DWT, then video construction. Different types of videos are introduced to test the system. The output compressed video is in a good quality and good performance as well as it has a specific compression ratio.

Ma, et al. [9] presents the multimedia compression techniques and multimedia transmission techniques and provided an analysis of energy efficiency when applied to limited resources platform. For the image compression they discussed three important technical JPEG2000, JPEG (DCT) (EBCOT) and SPIHT. They analyzed in their working efficiency in compression terms, the memory requirement and computational complexity. They concluded that SPIHT is the best choice for compression methods lower power consumption due to its ability to provide higher compression ratio with low complexity. JPEG2000 (EBCOT) hit a high compression ratio, which means better quality than SPHIT, but the burden of higher computation and power consumption for resource-limited systems, due to the complexity of operations EBCOT Tier-1 and Tier-2 caused intensive complex coding.

IV.PERCEPTUALLY DRIVEN ERROR PROTECTION: VIDEO CODEC ARCHITECTURE

After reviewing the most relevant video coding aspects and solutions related to perceptual error protection in the previous chapter, this chapter will present the high-level architecture of the proposed Perceptually Driven Error Protection (PDEP) video coding solution. The purpose of this description is to familiarize the reader with the codec's basic operation, identify the main functional modules involved in the encoding/decoding process and explain how these modules interact with each other. The main objective of this video coding solution is to maximize the overall RD performance under error-prone channel conditions, notably by minimizing the degradation of the decoded output video quality caused by packet losses during video transmission, based on the efficient use of the available rate-limited channel protection resources. The high-level architecture of the proposed PDEP codec is depicted in Figure 3. The main novel aspects of this codec regarding the literature are:

- Insertion on the error protection process of an improved perceptual weighting mechanism based on [11] using an architecture as proposed in [12].
- Improvement of the requantization approach used in by adding an alternative transcoding technique from those proposed in [13].

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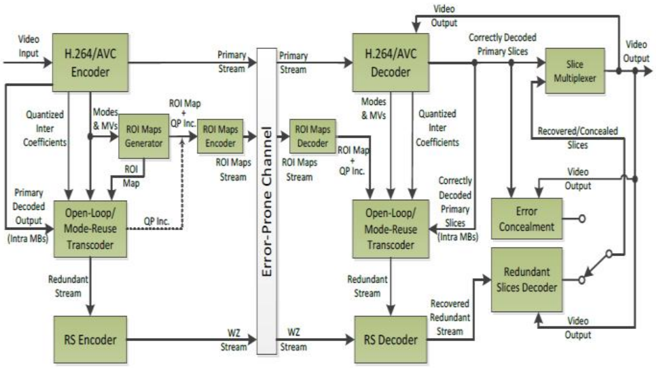

Figure 3: High-level architecture of the PDEP video codec

For a better understanding of the PDEP codec's basic operation, the following walkthrough provides a step-by-step description of the encoding and decoding processes.

The **PDEP encoder** proceeds as follows:

1. **H.264/AVC Encoding** – The input video sequence is firstly fed to a regular H.264/AVC encoder, in this case a High profile encoder, where the predictive video coding tools provided by the standard are applied to generate the primary compressed bitstream. The quality associated to this stream corresponds to the target quality for the application at hand and is controlled by setting the primary bitrate or the primary quantization parameter (QP). During the encoding process, the H.264/AVC encoder creates the following encoding information, which is relevant for the primary coded stream, but may also be provided to other encoder modules:
   a. **Macroblock Modes and Motion Vectors** – The encoder stores the partition modes and motion vectors (MVs), as well the Intra prediction modes for the Intra MBs selected for each encoded MB. This information is sent to both the Region Of Interest (ROI) Maps Generator and the Open-Loop/Mode-Reuse Transcoder modules; however, as explained later in this walkthrough, this information will be used for different purposes in each of them.
   b. **Quantized Inter Coefficients** – The encoder also stores the coefficients resulting from the quantization process of the Inter coded MBs and sends this information to the Open- Loop/Mode-Reuse Transcoder module.
   c. **Primary Decoded Output** – Being a typical predictive video encoder, the H.264/AVC encoder needs to internally replicate the output of the decoding process, in order to predict the next frames to code, based on the decoded information also available at the decoder. This decoded output information for Intra coded MBs is also sent to the Open- Loop/Mode-Reuse Transcoder.

The resulting primary stream is directly transmitted over an error-prone communication channel, where video packets are vulnerable to erasures due to the characteristic limitations of packet-based networks. Each encoded slice is transmitted on a single packet, meaning that the loss of one packet corresponds to the loss of an entire slice. In the adopted slice structure, each slice contains a fixed number of MBs corresponding to the width of a picture in MBs, meaning that each encoded slice represents one full row of MBs in the picture.

2. ROI Maps Generation – Based on the coding modes and MVs information provided by the H.264/AVC Encoder, the ROI Maps Generator decides whether a MB belongs to a perceptually relevant area of the picture (foreground area) or to a perceptually less important region (background area). To reduce the associated complexity, this perceptual analysis process is performed in the compressed domain which, naturally, limits the quality of the classification results. When all the MBs of a picture are perceptually evaluated, the ROI Maps Generator creates a simple binary map at the MB level where the MBs belonging to the foreground area are labeled with 1's and the MBs belonging to the background area are labeled with 0's. These maps are called ROI Maps and are sent to the Open-Loop/Mode-Reuse Transcoder to control the QP used in the redundant stream generation, this means to adjust the quality and rate of the redundant coding process to be error protected. The ROI Maps are also sent to the ROI Maps Encoder, to be compressed and sent to the decoder through the communication channel, so that the decoder may know which MBs belong to the foreground and background areas.

3. ROI Maps Encoding – Before sending the ROI Maps to the decoder, these maps are compressed to reduce the bitrate associated to its transmission. Considering these are very simple binary maps, the generic WinZip compression tool available in [14] is used to compress them. Two additional parameters described in the next step of this walkthrough, called the foreground and background QP increments, are compressed together with the ROI Maps and the resulting compressed stream is sent to the decoder.

4. Open-Loop/Mode-Reuse Transcoding – After receiving the ROI Maps from the ROI Maps Generator and the coding modes and MVs from the H.264/AVC Encoder, the Open-loop/Mode-Reuse Transcoder module creates a lower quality/rate version of the primary stream using two distinct transcoding methods (the differences will be detailed in Chapter 4):

a. Mode-Reuse Intra Transcoding – Based on the primary decoded output received from the H.264/AVC encoder, this technique is used to create a coarsely quantized representation of the primary stream for the Intra coded MBs

b. Open-Loop Inter Transcoding – This transcoding method uses the quantized Inter coefficients provided by the H.264/AVC encoder to create a coarsely quantized representation of the primary stream but only for Inter coded MBs, as the Intra coded MBs are addressed by the other transcoding solution .

The QP increment may be the same for all the MBs, meaning that no ROI Maps are exploited, or be different for the foreground and background regions, with a higher QP increment for the background MBs than for the perceptually most important MBs, as the first are perceptually less relevant. The QP increments for both background and foreground areas used in the transcoding process are appended to the ROI Map information and compressed together by the ROI Maps Encoder before they are sent to the decoder.

5. Reed-Solomon Encoding – After the transcoding process is applied to each entire picture, the Reed-Solomon (RS) Encoder applies a RS error correcting code across the redundant slices generated in the previous step. The parity information resulting from the RS encoding process is grouped into a special type of slices called parity slices. Together, these parity slices form the WZ Stream represented in Figure 3, which is sent to the decoder along with the primary and ROI Maps streams. It is important to emphasize that only the parity slices generated by the RS encoder are sent to the decoder in the WZ stream; the redundant stream used to generate this parity information is discarded after the RS encoding process, as it will be regenerated at the decoder based on the primary stream. Again, the WZ stream rate is a very important system parameter, as it controls the amount of error protection adopted for the redundant stream.

At the other side of the communication, the **PDEP decoder** receives the bit streams sent by the encoder and proceeds as follows:

1. H.264/AVC Decoding – The received primary stream is fed to a regular H.264/AVC decoder, High profile decoder in this case, in order to decode the primary slices that were not lost during the transmission. Similarly to the H.264/AVC Encoder, this decoder stores the coding modes, MVs and quantized Inter coefficients for each MB of the received primary slices, which are also provided to the Open-Loop/Mode-Reuse Transcoder. When losses occur, the missing parts of the affected picture are temporarily left empty.

2. ROI Maps Decoding – The received ROI Maps stream from the ROI Maps Encoder module at the encoder is decoded by the ROI Maps Decoder using the WinZip decoder tool to recover the original ROI Maps and QP increments. The decoded ROI Maps and QP increments are after sent to the Open-Loop/Mode-Reuse Transcoder module at the decoder.

3. Open-Loop/Mode-Reuse Transcoding – Using the correctly received decoded primary slices and the Inter quantized coefficients provided by the H.264/AVC decoder, the Open-Loop/Mode-Reuse Transcoder replicates the encoder generation of the redundant stream by repeating the transcoding process previously performed at the encoder. The ROI Maps and QP increments received from the ROI Maps Decoder are used to control the quality/rate of the redundant stream, forcing the redundant stream generated at the decoder to be exactly the same as the one generated by the transcoding module at the encoder. However, the transcoding process at the decoder can only be performed for the correctly received primary slices and not for the non-correctly received ones, which have to be recovered by other means. The resulting redundant stream for the received slices is used as systematic information by the RS decoder.

4. Reed-Solomon Decoding – At this point, the decoder has the redundant stream generated from the correctly received primary slices and the parity slices received through the WZ stream for each frame. With this information, the RS decoder performs erasure decoding across the correctly received redundant slices in an attempt to recover the erased redundant stream using the received RS parity data.

5. Redundant Slices Decoding – If the RS decoder succeeds, the recovered redundant slices are decoded by a standard H.264/AVC decoder using the previously decoded pictures as prediction references.

6. Error Concealment – In case the number of lost primary slices exceeds the correcting capacity of the applied RS code, the RS erasure decoding process fails. In this scenario, an error concealment mechanism based on the previously decoded pictures is used, in an attempt to fill in the missing visual information of the current picture.

7. Slice Multiplexing – Finally, the correctly received primary slices and the concealed/recovered ones are combined to generate the final decoded picture. This picture is internally stored and used as reference by the primary and redundant decoders for decoding the next frames and also by the error concealment mechanism.

From the above, it may be concluded that the main encoding parameters determining the final performance of the PDEP coding solution are:

- *Primary stream bitrate*, which defines the target quality and primary rate for the application at hand, notably for error free conditions.
- *QP increments for both the background and foreground areas*, which define the lower quality (and rate) for the redundant stream and thus the backup quality that should be recovered when some primary stream slices are lost. The higher this rate is, the lower will be the error protection for a fixed WZ stream bitrate.
- *WZ stream bitrate*, which defines the amount of resources invested in error protection; the total rate is the sum of the primary stream rate with the WZ stream bitrate and the ROI Maps stream bitrate.

V. CONCLUSIONS

The adopted test conditions were first described, followed by the performance results obtained with and without considering the perceptual weighting on the error protection mechanism. The perceptual classification mechanism was then integrated with the developed error protection solution to control the error protection mechanism, resulting in the final PDEP video codec. The proposed solution provides a very attractive alternative to the already available error protection solutions, given the high performance gains achieved with respect to the H.264/AVC+FEC and H.264/AVC+EC video coding solutions without considering the perceptual relevance of the video content.

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