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TRANSFORMING TECHNOLOGY, EXPLORING KNOWLEDGE

"A Novel Approach of Error Correction for Uncompressed HD Frame Over Wireless Network Based on Forward ECT"

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***Abstract* - Digital transmission of uncompressed high-definition video is challenging because of its high data rate and its extreme sensitivity to bit errors. In this paper we propose a simple error correction scheme to reduce the bit error effects in the video at the receiver end of a wireless channel. Our scheme uses the large amount of spatial redundancy already present in uncompressed HD video data to provide an extra layer of protection in addition to that provided by channel coding. Thus, our method requires no change to the video signal being transmitted and is compatible with any existing solution for HD video transmission. Our scheme effectively reduces the number of visible artifacts because of uncorrected channel errors and achieves improvement in peak signal to noise ratio. Our goal is to use the redundancy in the HD frame to correct the bits that are in error, using their correlation with their neighbors. Our scheme shows that it includes both MSBs and LSBs to compensate the error in frame.**

***Keywords**: Uncompressed HD frame, Error, YUV*

I. INTRODUCTION

We consider the problem of transmitting an uncompressed high definition (HD) frames over a wireless connection. This problem is motivated by the application scenario illustrated in Figure 1, where a HD source such as a Blu-ray disc is decrypted and decoded in a device that then transmits the uncompressed frame wirelessly to a HD display.

HDTV (High Definition Television) has become popular because it has higher resolution than traditional television systems and an aspect ratio of 16:9 influenced by widescreen cinema. Presently, the data rate of uncompressed HD video can be as high as 3.0 Gbps (1080p60, RGB444 pixel format at 8 bits per pixel). In the future, the data rate is expected to rise with increases in resolution and color depth. Since HD video sources require such large data rates, it may seem reasonable to compress the video stream before transmitting. However, compression introduces delay, reduces video quality and increases complexity at the transmitter (video source) and receiver (HDTV).

Also, the video display will have to support multiple codecs to maintain inter-operability with the various video sources.Furthermore, the HDMI connector interface for HD video sources and displays supports uncompressed HD transmission. Motivation to transmit uncompressed HD video and more information on disadvantages related to compression can be found in [2-5]. Random bit errors (especially in the most significant bits of a pixel) in an uncompressed HD frame are typically visible to the naked eye as "sparkles." Given the high user expectations for HDTV, it is critical that decoding failures in the digital communication scheme used to convey these bits be masked from the user.

This is especially important in applications where retransmission-based error recovery is not possible or desirable (e.g., when streaming to multiple screens). In this paper, we examine whether we can use the large amounts of redundancy in the uncompressed video to obtain low-complexity error resilience techniques to complement the error correction provided by channel coding.

While our approach is of general applicability, we are motivated by the recently developed Wireless HD (WiHD) standard, which supports the transmission of

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uncompressed HD content in the unlicensed 60 GHz frequency band [1], as shown in Figure 1.

While the 7 GHz of spectrum in this band makes it an attractive choice for bandwidth-hungry applications, a key challenge is the susceptibility to blockage by humans and furniture at these small carrier wavelengths. One approach to this problem is to use electronic beam steering to steer around obstacles, using reflections from walls or the ceiling. This introduces a significant amount of variability in the signal-to-noise ratio, making it important to employ error resilience at the source coding layer to minimize quality fluctuations.

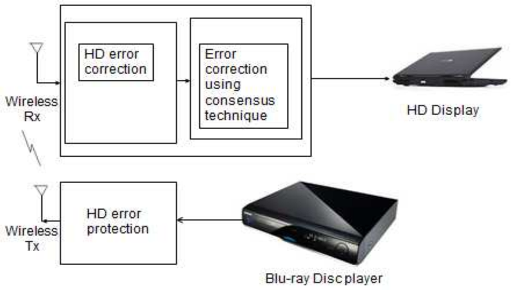

Fig.1.1- Existing system

Many error recovery techniques have been proposed to repair damaged video or frames. These techniques can be broadly categorized into groups by whether the encoder or decoder plays the primary role, or both are involved in cooperation with each other. Error control technique include Forward Error Correction (FEC), essentially, they all add redundancy in either the source coder or the transport coder to minimize the effect of transmission errors.

CHANNEL CODING

Channel coding is a technique used in digital communications to ensure a transmission is received with minimal or no errors. The various coding methods that can be employed are achieved by interweaving additional binary digits into the transmission. When decoded on the receiving end, the transmission can be checked for errors that may have occurred and, in many cases, repaired. Other times, the recipient simply asks for the transmission again.

ERROR RESILIENCE

The error resiliency schemes have also been used in the previous video coding standards whereas some others such as parameter sets, redundant slices are either new or are implemented differently like correcting frames which are in bit errors by using error correction technique [8] and by using denoising techniques.

For uncompressed HD frames the quality of video streams is highly vulnerable to channel disturbances when they are transmitted over an unreliable medium such as a wireless channel and they result in bit errors so we propose a simple error correction technique to reduce the bit errors in the HD frames.

II. MODEL TO ANALYZE ERROR CORRECTION TECHNIQUE

The YUV model defines a color space in terms of one luminance and two chrominance components. YUV models human perception of color more closely than the standard RGB model used in computer graphics hardware. Y stands for the luminance component (the brightness) and U and V are the chrominance (color) components. Concretely, U is blue-luminance difference and V is red-luminance difference. YUV model is shown in Figure 2.

YUV color space typically used as part of a color image pipeline it encodes a color image or video taking human perception into account, allowing reduced bandwidth for chrominance components, thereby typically enabling transmission errors or artifacts to be more efficiently masked by the human perception than using a "direct" RGB-representation. Other color spaces have similar properties, and the main reason to implement or investigate properties of Y'UV would be for interfacing with analog or digital television or photographic equipment that conforms to certain Y'UV standards.

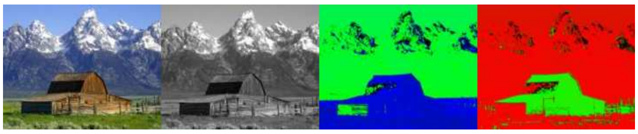

Fig.1.2 - YUV model

Matrix to YUV (YCbCr): In order to allow a compatible migration from black & white television to color television the YUV color space was utilized. Y stands for the luminance (lightness) information, and is compatible to black & white (and gray) signal. U and V are the so-called color difference signals B-Y an R-Y, and carry the additional color information (additive color space).

The YUV representation of video information is also oriented on the human perception of visual information, whereby RGB representation is more based on the technical reproduction of color information. The human

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eye senses luminance and color with different receptors. There are less color receptors, and they have significant less spatial resolution. The YUV color space representation can take advantage of that fact, by spending less bandwidth for color difference information than for luminance information. Luminance Y can be positive only the color difference signals U and V can be positive or negative. Commonly YUV is also normalized to unity (peak-to-peak = 1).

The following matrix equation transforms gamma-pre-corrected and normalized RGB into normalized YUV

$$Y = 0.299 * R + 0.587 * G + 0.114 * B \quad (2.1)$$

$$U = Cb = (B - Y) = -0.169 * R - 0.331 * G + 0.500 * B \quad (2.2)$$

$$V = Cr = (R - Y) = 0.500 * R - 0.419 * G - 0.081 * B \quad (2.3)$$

U and V form a square color plane. But for colors of natural pictures, this square color plane is reduced to a color circle plane. The vectors of natural colors don't point into the extreme corners of the square UV plane. The size of that circle is further restricted, if luminance values are close to minimum or maximum. There can't be any color in black or white eg (Artificial YUV signals, e.g., test signals can use those extreme combinations).

The YUV color space is best represented by a round column, with the dimension of luminance Y as axle in its center, and this round YUV color space column is shaped to a point at the bottom and at the top.

Color Correction: Each spot sampled is a pixel in a digital frame. These raw RGB samples are a measure of color density at a spot on a frame. They need to be corrected, possibly reversed, and manipulated to present a pleasing video image. Pixel is the smallest unit of a digital video frame. A pixel contains three values. These values either represent RGB or YUV.Y'CBCR or YUV is the color space in which many digital video formats store data. Three components are stored for each pixel—one for luma (Y) and two for color information (CB for the blue difference signal and CR for the red difference signal) which forms RGB Red, Green, and Blue. The RGB color space has a very large gamut, meaning it can reproduce a very wide range of color , however each must be fully sampled requiring a high data rate.

For each color channel component of a pixel, the range of possible values is determined by the number of bits used to define the value. The bit depth is usually 8 or 10 bits.

For each digital pixel of resolution a sample is taken from a constantly moving beam of light which is emitted by a CRT through the film. The beam or "spot" is then split into its primary colors Red, Green and Blue. Each color sampled by a PEC (photo sensor). For 1080p video frame, the beams R, G, and B values are sampled 2,073,600(1920x1080) times per frame.

YUV Frame class is a representation of one frame in YUV color space. The constructor allows to choose between 4:4:4 or4:2:0 planar and set the dimensions of the frame (width and height). The dimensions of the frame and its three different components can be obtained or set with the different getters and setters methods. The complete image is stored in a byte array. In addition, the class implements methods to convert the color space between YUV 4:4:4 planar and YUV 4:2:0 planar.YUV Reader implements the basic functions to read, write and send YUV image stream from different sources. This class avoids repeat code in several classes quite similar that can use these functions inheriting from the super class YUV Reader. The basic functions are protected and only inhered classes can use them. YUV File Reader is a class allows to read a YUV video stream from a file. This file must be uncompressed and its color space should be YUV 4:2:0 planar or 4:4:4 planar.

Frequency shift keying (FSK) is the most common form of digital modulation in the high-frequency radio spectrum where digital information is transmitted through discrete frequency changes of a carrier wave. Binary FSK (usually referred to simply as FSK) is a modulation scheme typically used to send digital information between digital equipment .The data are transmitted by shifting the frequency of a continuous carrier in a binary manner to one or the other of two discrete frequencies. One frequency is designated as the "mark" frequency and the other as the "space" frequency. The mark and space correspond to binary one and zero, respectively. By convention, mark corresponds to the higher radio frequency.

III. EXISTING ERROR CORRECTION TECHNIQUE

Consider 1080p25 HD videos with frame size of 1920x1080 pixels encoded as RGB444 with 8 bits per pixel. In an 8-bit pixel, the four most significant bits (MSBs) are more important to protect than the four least significant bits (LSBs), since errors in the four MSBs give rise to visible artifacts. In this error correction technique is based on the fact that most of the pixels in a HD video frame are very similar to the spatially adjacent pixels. We analyzed some HD video frames to quantify

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the amount of spatial redundancy. We found that around 95% of the pixels in a frame match the pixels to their north, south, east and west in the first MSB. Note that when the MSB in the pixels do not match, it does not make sense to look for matches among less significant bits. Among the pixels where the first MSB matches its neighbors, about 91% match in the second MSB as well.

Similarly, among the pixels where the first two MSBs match, around 85% match in the third MSB, and around 70% match in the fourth MSB given that the first three MSBs match. The match varies between 10-50% for the four LSBs, which is very low when the total number of pixels in the frame is considered. Hence, they attempt to correct as many bit errors as possible in the four MSBs, and, in keeping with our conservative approach, do not attempt to correct the LSBs. We now use this redundancy to design a simple error correction scheme.

Rule for Comparison	Surrounding pixels do not match in 4 MSBs	Surrounding pixels match and is equal to the center pixel in 4 MSBs	Surrounding pixels match and is not equal to the center pixel in 4 MSBs
All	45.91%	53.21%	0.86%
Majority	5.48%	83.68%	10.83%

Table 3.1 - Comparison of 'ALL in consensus' rule and 'MAJORITY in consensus' rule.

Table 1 compares two candidate methods: the 'All in consensus' and 'Majority in consensus' rules. Even though 'Majority in consensus' appears to work well because it has almost twice the amount of 'surrounding pixels match and equal' to the center pixel in four MSBs compared to 'All in consensus', it has almost ten times 'surrounding pixels match and not equal' to the center pixel in the four MSBs. In fact, 'Majority in consensus' rule actually results in increased number of bit errors after correction. Since our application requires a highly conservative rule for bit flipping, we choose the 'All in consensus' rule for our algorithm.

The algorithm works as follows:

1. For every video frame, failure of the RS decoder indicates the bits that are marked as possibly in error.
2. We check if the previous significant bit positions have equal values in all the four surrounding pixels and in the current pixel.
3. If the previous bits match in all the five pixels
4. under consideration, we check the current marked bit position, in the four surrounding pixels.
5. If the values of the bit position checked in the four surrounding pixels are ALL equal, we say that these bits are in consensus.
6. If the value of the consensus bits is different from the value of the marked bit, we flip the marked bit.
7. If the value of the consensus bits is same as the value of the marked bit, we do not change the value of the marked bit.
8. We do not try to correct marked bits in any of the four LSBs.

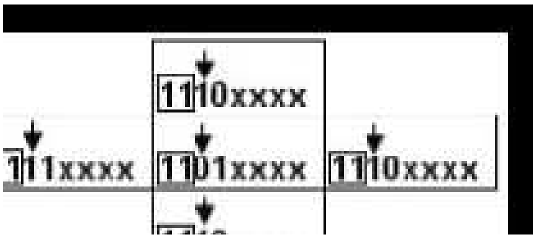

Figure 3.1 - 'ALL in consensus rule' is used for error correction. The bit position 5 (third MSB) of the centre pixel is marked.

In the example shown in Figure 4, the 3rd significant bit in the center pixel (0 in 1101xxxx) is marked as a potential bit error. Checking the first 2 MSBs in the four surrounding pixels, we find that they match the current pixel ('11' as shown in the example).

The current bit (marked by the arrow) is now checked against the surrounding pixels. Since they are all equal (1 in this case), we have a consensus. However, the consensus differs from the value of the marked bit (0 in this case), so we flip this bit. Hence, the value of this pixel after correction is 1111xxxx.

IV. PROPOSED TECHNIQUE

We consider 1080p HD frame size of 1920x1080 pixels with 8 bits per pixel. In an 8-bit pixel, there are four most significant bits (MSBs) and four least significant bits (LSBs).Using our error correction technique we try to reduce as much possible bit errors in four most significant bits (MSBs) and four least significant bits (LSBs). Our error correction technique is based on the

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fact that most of the pixels in a HD frame are very similar to the spatially adjacent pixels. We analyzed some HD frames to quantify the amount of spatial redundancy. We found that around 95% of the pixels in a frame match the pixels to their north, south, east and west in the first MSB.

Note that when the MSB in the pixels do not match, it does not make sense to look for matches among less significant bits. Among the pixels where the first MSB matches its neighbors, about 91% match in the second MSB as well. Similarly, among the pixels where the first two MSBs match, around 85% match in the third MSB, and around 70% match in the fourth MSB given that the first three MSBs match.

The match varies between 10-50% for the four LSBs. Hence, we attempt to correct as many bit errors as possible in the four MSBs and four LSBs. We now use this redundancy to design a simple error correction scheme.

	First MSB	Second MSB	Third MSB	Fourth MSB	Four LSBs
HD Frame	95%	90%	85%	70%	10 – 50%

Table 4.1 - HD Frame where pixels match with their adjacent pixels

V. Simulation Results

We use frames of the standard 1080p, 25 HD with YUV pixel format:

1. Car
2. Blue sky
3. Sun Flower
4. Station
5. River Bed

S.NO	IMAGE	TOTAL NO OF FRAMES	PSNR VALUE BEFORE CORRECTION	PSNR VALUE AFTER CORRECTION
1	CAR	120	18.24	24.03
2	BLUE SKY	250	19.38	23.98
3	SUN FLOWER	500	19.01	23.63
4	STATION	313	19.96	24.62
5	RIVER BED	250	19.63	24.50

Table 4.2 - Comparison of PSNR values with various images

CAR FRAME

Total number of frame=120

1920x1080

Fig. 5.1 - Car frame before correction

Fig. 5.2 - Car frame after correction

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BLUE SKY FRAME

Total number of frame=120

1920x1080

Fig. 5.3 - Blue sky frame before correction

Fig. 5.4 - Blue sky frame after correction

SUNFLOWER FRAME

Total number of frame=500

1920x1080

Fig. 5.5 - Sunflower frame before correction

Fig. 5.6 - Sunflower frame after correction

STATION FRAME

Total number of frame=313

Fig. 5.7 - Station frame before correction

Fig. 5.8 - Station frame after correction

VI. CONCLUSION

Thus our Error Correction technique takes advantage of the spatial redundancy in the HD frames to correct the bits that are in error, using their correlation with their neighbours .Thus our technique shows that it includes both MSBs and LSBs to compensate the error in HD

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frames and effectively reduces the number of visible artifacts and achieves improvement in the PSNR. Simulation modulation scheme, YUV read function for YUV file and Error Correction technique is simulated on MATLAB Tool. Our simulation result shows that the number of visible artifacts reduced in the five frames (Car, Blue Sky, Sunflower, Station, River Bed) after correction.

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