International Journal of advancement in electronics and computer engineering (IJAECE)
Volume 1, Issue 4, July 2012, pp.126-131, ***ISSN 2278 -1412***

Analysis of Error Control for Uncompressed HD Frames Over Wireless Home Networks

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Abstract *– In wireless home network, digital transmission of uncompressed high-definition frames are challenging because it is extremely sensitivity to bit errors. We attempt to reduce the bit error effects in the HD frames at the receiver end on Wireless home network using error correction technique. 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*: HD, Error, YUV , relay.*

I. Introduction

Recent developments in digital camera technology allows the generation of images with very rich color information. In this sense, some approaches have been proposed to exploit RGB inter-component redundancy, reducing spectral correlation without resorting to YUV transformation. In [1], RGB components are uncorrelated by computing parameters that define linear relationships between them and are transmitted to the decoder. Nevertheless, because of its good decorrelation capabilities, the use of a luminance (Y) and two chrominance components (Cb, Cr), is usually regarded as a better option for image coding.

In the YUV space, chrominance signals have usually small dynamic range and smooth variations having consequently considerably less information than luminance. Most of the spatial information is in the luminance signal that is also the most important for the human visual system. Thus, in most image coding schemes, Cb and Cr chrominance signals are sub-sampled, in order to achieve better performance with negligible visual degradation. Often, both chrominance signals are sub-sampled by a factor of two in the vertical and horizontal directions, which is called Y Cb Cr 4:2:0 chroma formats. Due to the high degree of decorrelation achieved by the YUV format, the exploitation of inter-channel correlation between YUV channels has been considered. However, a recent proposal [2], demonstrated that it may be worthy to exploit some of the residual inter-channel correlation that still exists among the YUV signals. Thus, new methods that reduce the correlation between YUV channels are worth investigating.

YUV file format are shown in [3][4]. YUV test sequences are available in [5] [9].

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.

Our goal is to reduce the bit error effects in the uncompressed HD frames in wireless home networking using error correction technique. Our technique includes both most significant bits (MSBs) and least significant bits (LSBs) to compensate the error in the frame and effectively reduces the number of visible artifacts present in the HD frames.

II. Different Technologies

II.1. UWB Technology

UWB is a unique and new usage of a recently legalized frequency spectrum. UWB radios can use frequencies from 3.1 GHz to 10.6 GHz – a band more than 7 GHz wide. Each radio channel can have a bandwidth of more than 500 MHz, depending on its center frequency. To allow for such a large signal bandwidth, the FCC put in place severe broadcast power restrictions. By doing so, UWB devices can make use of an extremely wide frequency band while not emitting enough energy to be noticed by narrower band devices nearby, such as 802.11a/b/g radios. This sharing of spectrum allows devices to obtain very high data throughput, but they must be within close proximity.

UWB's low power requirements make it feasible to develop cost-effective CMOS implementations of UWB radios. With the characteristics of low power, low cost, and very high data rates at limited range, UWB is positioned to address the market for a high-speed WPAN.

UWB technology also allows spectrum reuse. A cluster of devices in proximity (for example, an entertainment system in a living area) can communicate on the same channel as another cluster of devices in another room (for example, a gaming system in a bedroom). UWB-based WPANs have such a short range that nearby clusters can use the same channel without causing interference. An 802.11g WLAN solution, however, would quickly use up the available data bandwidth in a single device cluster, and that radio channel would be unavailable for reuse anywhere else in the home. Because of UWB technology's limited range, 802.11 WLAN solutions are an excellent complement to a WPAN, serving as a backbone for data transmission between home clusters.

II.2. WLAN Technology

One of the most used WLAN technologies is defined in IEEE 802.11b. The standard was completed in 1999 and a wide range of products exists since 2001. For radio access this standard defines three Frequency Hopping CDMA coded channels in unlicensed 2.4 GHz frequency band. It allows the wireless transmission of approximately 11 Mbps of raw data at distances from tens up to hundred meters. The distance depends on impediments, materials, and line of sight while the transmission rate depends strongly on usage of common unlicensed radio channel. Most wireless LAN installations today comply with 802.11b, which is also the basis for Wi-Fi certification from the Wireless Ethernet Compatibility Alliance (WECA).

The initial version of the IEEE 802.11b achieves only 1 Mbps with BPSK and 2 Mbps with QPSK over both FHSS (Frequency Hopping Spread Spectrum) and DSSS (Direct Sequence Spread Spectrum). The task group for 802.11b was responsible for enhancing the initial 802.11 DSSS PHY to include 5.5 Mbps and 11 Mbps data rates to finalize the standard (IEEE Std. 802.11b-1999) in late 1999.At present FHSS is not longer used. To provide the higher data rates, 802.11b uses CCK (Complementary Code Keying), a modulation technique that makes efficient use of the radio spectrum.

IEEE 802.11a defines an updated version of 802.11b standard in order to achieve higher data rates and enhanced security. The standard has been completed in 1999 and products are available now. The 802.11a uses 8 – 12 available radio channels in the low – medium UNII frequency band at 5.2 GHz and achieves data throughput up to 54 Mbps. Products based on the IEEE's 802.11a standard cannot interoperate with slower 802.11b units because they run on different bands. The 802.11a standard is using Orthogonal Frequency Division Multiplexing (OFDM). 802.11a supports data rates ranging from 6 to 54 Mbps. Because

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of operation in the 5 GHz bands, 802.11a offers much less potential for radio frequency (RF) interference than other PHYs (e.g. 802.11b and 802.11g) that utilize 2.4 GHz frequencies. With high data rates and relatively little interference, 802.11a does a great job of supporting multimedia applications and densely populated user environments. This makes 802.11a an excellent long-term solution for satisfying current and future civilian requirements. It specifies 8 available radio channels (available radio spectrum in some countries would permit the use of 12 channels – the US 5 GHz Unlicensed Band supports 12 non-overlapping 802.11a networks).

III.3. 60 GHz and Wireless HDMI Technologies

The millimeter wave spectrum at 30-300 GHz is of increasing interest to service providers and systems designers because of the wide bandwidth available for carrying communications at this frequency range. Such wide bandwidths are valuable in supporting applications such as high speed data transmission and video distribution. The 60 GHz frequency band, which provides up to 7 GHz of unlicensed bandwidth, is a highly promising resource for future wireless short-range transmission. Despite millimeter wave (mm Wave) technology has been known for many decades, the mm Wave systems have mainly been deployed for military applications. With the advances of process technologies and low-cost integration solutions, mm Wave technology has started to gain a great deal of momentum from academia, industry, and standardization body. In a very broad term, mm Wave can be classified as electromagnetic spectrum that spans between 30GHz to 300 GHz, which corresponds to wavelengths from 10mm to 1mm. In this paper, however, we will focus specifically on 60GHz radio (unless otherwise specified, the terms 60 GHz and mm Wave can be used interchangeably), which has emerged as one of the most promising candidates for multi gigabit wireless indoor communication systems.60 GHz technology offers various advantages over current or existing communications systems .One of the deciding factors that makes 60 GHz technology gaining significant interest recently is due to the huge unlicensed bandwidth (up to 7 GHz) available worldwide. While this is comparable to the unlicensed bandwidth allocated for ultra-wideband (UWB) purposes, 60GHz bandwidth is continuous and less restricted in terms of power limits. This is due to the fact that UWB system is an overlay system and thus subject to very strict and different regulations. The large bandwidth at 60 GHz band is one of the largest unlicensed bandwidths being allocated in history. This huge bandwidth represents high potentials in terms of capacity and flexibility that makes 60 GHz technology particularly attractive for gigabit wireless applications. Furthermore, 60 GHz regulation allows much higher transmit power compared to other existing wireless local area networks (WLANs) and wireless personal area networks (WPANs) systems. The higher transmit power is necessary to overcome the higher path loss at 60 GHz. While the high path loss seems to be disadvantage at 60GHz, it however confines the 60 GHz operation to within a room in an indoor environment. Hence, the effective interference levels for 60 GHz are less severe than those systems located in the congested 2–2.5GHz and 5–5.8 GHz regions. In addition, higher frequency reuse can also be achieved per indoor environment thus allowing a very high throughput network. The compact size of the 60 GHz radio also permits multiple antennas solutions at the user terminal that are otherwise difficult, if not impossible, at lower frequencies. Comparing to 5GHz system, the form factor of mm Wave systems is approximately 140 times smaller and can be conveniently integrated into consumer electronic products. It is intended to be used for high-rate wireless networks (Wireless Local Area Network (WLANs), Wireless Personal Area Network (WPANs)) as well as for ultra-high rate point-to-point links, addressing applications like high-definition (HD) video streaming.

III. Analysis of Error Correction Technique

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 4.1, 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.

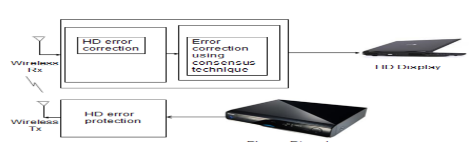

Fig.1. Existing system

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 (HD display). Also, the video display will have to support multiple codec to maintain inter-operability with the various video sources. Furthermore, the HDMI (High-Definition Multimedia Interface) connector interface for HD video sources and displays supports uncompressed HD transmission.HDMI supports, on a single cable, any uncompressed PC video format, including standard, enhanced, high definition video signals.

III.1 Existing Error Correction Technique

Considering 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). In existing error correction technique trying to reduce as much possible bit errors in four most significant bits (MSBs) and not in four least significant bits (LSBs).

- Checking if the previous significant bit positions have equal values in all the four surrounding pixels and in the current pixel.
- If the previous bits match in all the five pixels under consideration, we check the current marked bit position, in the four surrounding pixels.
- If the values of the bit position checked in the four surrounding pixels are ALL equal, we say that these bits are in consensus.
- If the value of the consensus bits is different from the value of the marked bit, we flip the marked bit.
- 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.
- Do not try to correct marked bits in any of the four LSBs.

TABLE I

1110xxxx	1110xxxx	1110xxxx
1111xxxx	C=1101xxxx	1110xxxx
1110xxxx	1110xxxx	1110xxxx

Example: current Pixel C = 1101xxxx

III.2. 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 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.

TABLE II

	First MSB	Second MSB	Third MSB	Fourth MSB	Four LSBs
HD Frame where pixels match with their adjacent pixels in four MSBs and four LSBs	95%	90%	85%	70%	10 – 50%

HD Frame where pixels match with their adjacent pixels

YUV: 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 4.8.

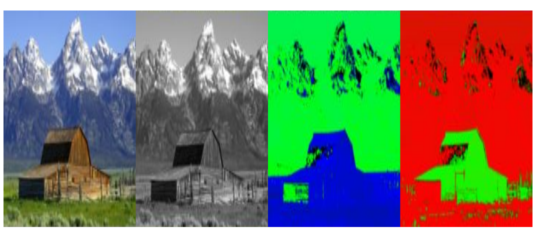

Fig.2. YUV model

IV. Simulation Results

We use frames of the standard 1080p25 HD with YUV pixel format:

- Car
- Blue sky
- Sun Flower
- Station
- River Bed

Total Number of Frames = 120
Frame Number =120
Size 1920×1080

Fig.3. Car Frame Before Correction

Total Number of Frames = 120
Frame Number =120
Size 1920×1080

Fig.4. Car Frame After Correction

Total Number of Frames = 250
Frame Number =120
Size 1920×1080

Fig.5. Blue sky Frame Before Correction

Total Number of Frames = 250
Frame Number =120
Size 1920×1080

Fig.6.Blue sky Frame After Correction

V. Conclusion

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 neighbors. Thus our technique shows that it includes both MSBs and LSBs to compensate the error in the HD frames and effectively reduces the number of visible artifacts and achieves improvement in the PSNR. Simulation modulation scheme, YUV read function for YUV files 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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