YCbCr Colour Watermark Embedding in Digital Video for Copyright Protection using Zero Padding

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***Abstract*—Digital watermarking is a vital process of shielding the intellectual property and copyright of the digital media. In this paper, a new digital video watermarking algorithm Colour Watermark Embedding Algorithm (CWEA) is proposed. CWEA has two important parts. First, YCbCr colour format is used to insert the variable size watermark. Second, Embedding of detail coefficients of LUMINANCE (Y-luminance) of watermark into the detail coefficients of CHROMINANCE (Cb and Cr- chrominance) of identical frames (I-Frames) of digital video. Data is inserted into the detail coefficients based on the energy of high frequency. A number of tests have been executed for most video-frame manipulations and attacks. All these tests are also performed on CWEA and it provides good results. In this paper, non-blind and semi-blind watermarking systems are used where non-blind watermarking mechanism has been proven to be robust, imperceptible and efficient to protect the copyright of H.264 and MPEG-4 coded video within the video retrieval system.**

***Index Terms*— Copyright Protection; DWT; LL Sub-Band; RGB; YcbCr; ZP.**

I. INTRODUCTION

Nowadays, a large amount of multimedia data has been exchanged over the internet and many internet users are sharing their images, videos and audios. Security provided to protect shared and transferred data over the internet is not enough. The main focus of the paper is on the Copyright Protection technique [1]-[5] of data security in Digital Videos. For this, Digital Watermark or digital pattern (text, image, audio or Video) is inserted inside Digital Video Frames. An attacker may crack, damage or detect watermark, but in this algorithm, it is very difficult to detect the original pattern of inserted watermark [6]-[9]. This algorithm improves the imperceptibility, robustness and security of inserted watermark. Block diagram of video watermarking is shown in figure 1. To extract the watermark, the watermark detection algorithm is applied on watermarked video.

In this paper, size of colored watermark is arbitrary. YCbCr color format is used to increase imperceptibility. ZERO PADDING (ZP) technique is applied to ensure the authorized owner of the video. In this paper, digital video copyright protection using DWT is proposed. This approach provides high PSNR and low MSE. Extraction of I-frame, watermark preprocessing [7]-[15], color watermark embedding [16]-[18] and extraction [19]-[24] are implemented in this paper. This platform embeds a color watermark in video for copyright protection to satisfy the client's requirements and then, watermark is extracted from the original source video to authenticate the copyright. Extracted watermark is compared with original watermark to verify whether product is authorized or not.

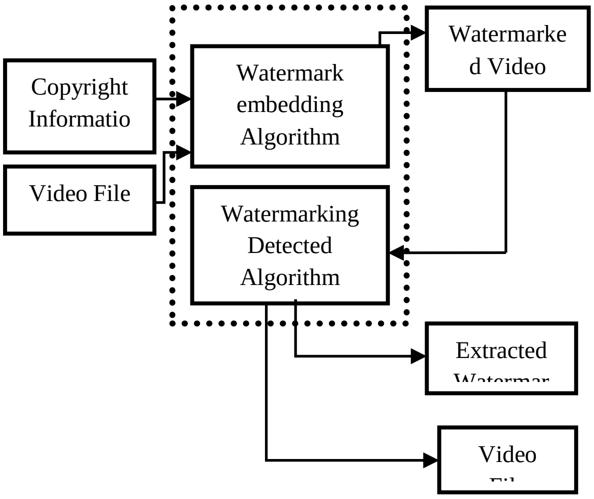

Figure 1: Video Watermarking

The rest of the paper is organized as follows: Section 2 shows the related work of copyright protection. In Section 3, the proposed scheme is illustrated which explains the embedding and extraction of the watermark from video sequence. Section 4 shows some experimental results and evaluates the performance of the proposed technique. At the end, conclusions are drawn in Section 5.

II. RELATED WORK

The future growth of the domestic digital copyright protection products basically depends on Real Network and Microsoft Windows Media. Large numbers of these products follow only the protection of copyright of electronic publications, magazines, journals and static images. But still, the necessity of such a platform exists which can apply the copyright protection on digital videos professionally. For detection process of the watermark, Data hiding techniques can be divided into three categories: Blind, Semi-blind, and non-blind.

In blind systems, the original data is not required to extract the watermark while in non-blind systems; original data is needed to decode the watermark. Whereas semi-blind watermark system necessitates some information about the original host data (but not the entire host data). In the literature review, we have studied that an attacker may be crack, damage or detect watermark with the help of some possible algorithms. But in CWEA, it is very difficult to detect the original pattern of inserted watermark. In this paper, we have improved the robustness and security of the inserted digital pattern or watermark and transparency of watermarked media.

III. Proposed Approach

In the proposed method, a colored image is used as a watermark which makes the system more robust. RGB image is converted into YCbCr format because HVS (Human Visual System) is more sensitive to luminance than color. In RGB, all colors are of the same resolution, while in YCbCr, LUMA (Y) has high resolution and CHROMA (Cb & Cr) has lower resolution.In the transmission/storage, YCbCr needs to transmit only Cb and Cr components while in RGB, R,G & B all the components are need to be transmitted because Cb + Cr + Cg = 1. So, Cg = 1- (Cb + Cr). As CHROMA has lower resolution so embed the watermark inside the Chrominance of the original frame.

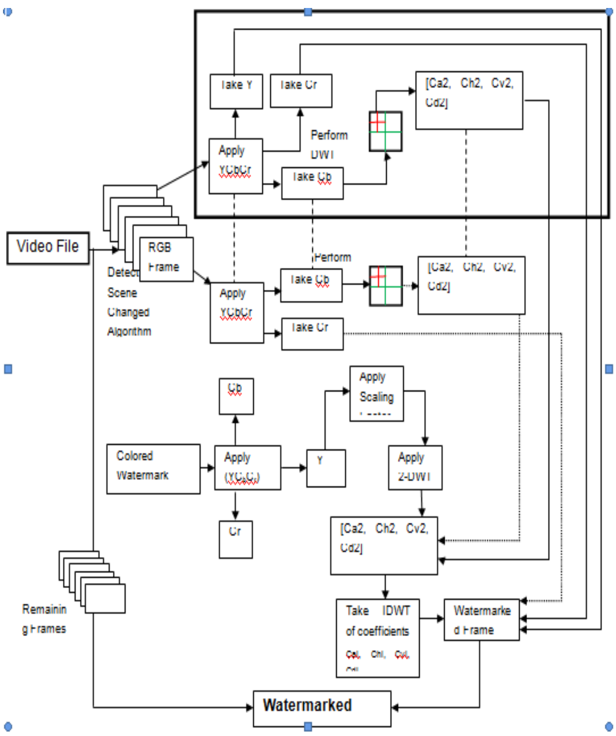

Figure 2: Video and Watermark preprocess

For embedding the watermark, 'Car race' video sequences are taken. After applying scene changed algorithm on video sequence, 97 scenes changed frames are obtained. Before embedding, watermark and input video are preprocessed. In Figure 2, a scene changed detection algorithm is applied on input video sequence and get the non-overlapping GOP [10]. Select the I-frame with the help of the frame selection scheme. After getting the I-frames, Each RGB frame is converted into YCbCr format. Then Apply 2-level DWT on Cb and Cr part of I-frame and obtain the higher (HH HL) and lower frequency band (LL LH) [11], 12]. After performing 2-DWT on each I-frame (Identical Frame) of video, we get LL-2 (2nd Level low frequency band), which is named as (Lf_2). Then 2-DWT technique is applied on each splitted watermark block and LL-2 is obtained, which is named as (Wm_2) and multiplied by a scaling factor β. After getting scaled (Wm_2) and (Lf_2), add them with the help of ZPA then apply IDWT (Inverse discrete wavelet transform) on video frame (Lf_2) and the result stores in WmI_i.

$$WmI_i = \left(Lf_{2_i}\right) + \beta \times \left(Wm_{2_i}\right) \quad (1)$$

$$W_{video} = \sum_{i=1}^{m} \left[\left(Lf^{i}_{2}\right) + q \times \left(Wm^{i}_{2}\right)\right] \quad (2)$$

A. *ZPA (Zero Padding Algorithm)*

Embedding Algorithm

1. Apply a scene changed detection algorithm [6] on the original video sequence (O_{video}) and then divide the each scene into non-overlapping group of pictures. Each group of pictures has an Identical frame (I). Select all I frames from input video for embedding the watermark.
2. Take each I-frame and apply YCbCr color format on each frame.
   Where Y= 0.299R + 0.587G + 0.114B
   Cb = 0.564 (B – Y)
   Cr = 0.713 (R – Y)
   Cb + Cr + Cg = 1
   Cg = 1 – (Cb + Cr)
3. Apply 2-level DWT on CHROMINANCE (Cb & Cr-chrominance) of each frame and store LUMINANCE (Y-luminance) for future reference.
   DWT (Cb) = $[Cai,Chi,Cvi,Cdi]_o$
   DWT (Cr) = $[Cai,Chi,Cvi,Cdi]_o$
   Where i=1, 2.
   [p q]= size(ch_i)
4. Let W = Digital Watermark Color Image. Take YCbCr of RGB-frame. Apply 2-level DWT on LUMINANCE component and get detail coefficients of LUMINANCE.
   DWT (Y) = $[Cai, Chi, Cvi, Cdi]_w$
   Where i= 1, 2.
   [x y] = size (Ch_j)=W
   ZERO PADDING in watermark:
   Z= zeros(p,q) and size of W= [x y]
   Insert the values of Wb in Z.
   Row value insertion at $Z\left(\frac{p-x}{2}+1:\frac{p-x}{2}+x\right)$
   Column value insertion at $Z\left(\frac{q-y}{2}+1:\frac{q+y}{2}\right)$
5. To embed the watermark in each I-frame, add detail coefficients of LUMINANCE of watermark with the detail coefficients of CHROMINANCE of I-frame of original video.
   Now, for Cb
   $[\text{Mod Chi}]_{Cb} = [\text{Chi}]_o + [\text{Chi}]_w$
   $[\text{Mod Cvi}]_{Cb} = [\text{Cvi}]_o + [\text{Cvi}]_w$
   Now, for Cr
   $[\text{Mod Chi}]_{Cr} = [\text{Chi}]_o + [\text{Chi}]_w$
   $[\text{Mod Cvi}]_{Cr} = [\text{Cvi}]_o + [\text{Cvi}]_w$
   Where i= 1, 2.
6. Now, mod Chi and mod Cv_i are the modified coefficients of CHROMINANCE of watermark inserted identical frame.
7. Take IDWT of watermark inserted CHROMINANCE components of identical frames. Finally, get the modified CHROMINANCE (mod Cb and mod Cr) of I-frame.

8. Take LUMINANCE (Y) from step-2 and add this with the modified CHROMINANCE (mod Cb and mod Cr) and get watermark inserted I-frame. Convert YCbCr format to RGB.
9. Combine all the watermark inserted I-frame with the remaining frames and get watermarked video for transmission/braodcastingvideo sequence (O_{video}) and Watermark (W) [256, 256]

B. Detection Algorithm

1. Apply a scene changed detection algorithm [6] on W_{video}. Each group of pictures has an Identical frame (I). Select all I frames from input watermarked video for detecting the watermark.
2. Take the watermarked frame (W_f) (Identical frame) and original identical frames (I_i). Apply YCbCr color format on both.
3. Apply DWT of CHROMINANCE of both watermarked frame and identical frames.
4. Subtract detail coefficients of CHROMINANCE of watermarked frame from the detail coefficients of original I-frame which are mod Ch_i, mod Cv_i, Ch_i and Cv_i respectively.
   Now, for Luminance
   $[NewCh_i]_{dw} = [\text{mod } Ch_i]_{ew} – [Ch_i]_o$
   $[NewCv_i]_{dw} = [\text{mod } Cv_i]_{ew} – [Cv_i]_o$
   where i= 1, 2.
5. Take IDWT of detail coefficients of detected LUMINANCE and add this detected LUMINANCE with the original CHROMINANCE and get the YCbCr format of detected watermark.
6. Calculate cross correlation between new values of detected watermark and the original watermark.
7. If correlation = high
   Then, Stop the execution. Detected watermark is similar to original watermark.
   else
   Take both detail coefficients together and repeat from step 3 (initially i=1 and in repetition process the value of i=2.
   Else if
   Take 2-level detail coefficients and repeat from step 3 until the detected watermark will get similarity with original watermark.
   else
   Watermark not found.

IV. Experimental Results and Analysis

To implement this technique, original videos ‘car_race.mp4’ at the dimension of 640 x 360 is used and the size of the original watermark image is 256 x 256 x 3. Figure 3 shows the original video frame and Y,Cb, Cr components. Figure 4 shows original video frames and their 2-Level de-compositions. In figure 4(b), there are two types of rectangle blocks, the first one is named as [LL-1 LH-1 HL-1 HH-1] and second is named as [LL-2 LH-2 HL-2 HH-2]. LL-2 is known as the approximate coefficient of 2nd level where embed the watermark information and rest are detailed coefficients of 2nd level. Figure 5 shows colored watermark image. Applied watermark detection algorithm on all the watermarked I-frames. Figure 6 shows original and detected watermark. If the PSNR (Peak Signal to Noise Ratio) of watermarked video is high, it means the original and watermarked videos are same. So watermark is not visible.

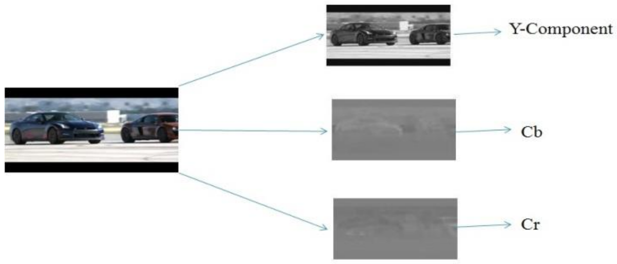

Figure 3 : Original car race video frame and LUMA and CHROMA components

Figure 4 (a): Original car race video frame

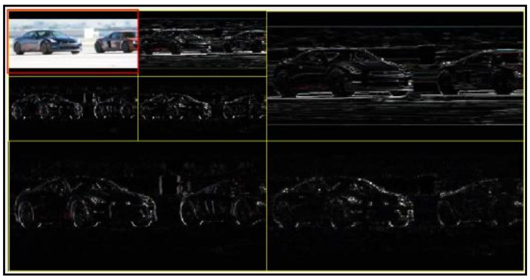

Figure 4 (b): 2-level decomposition of car race video

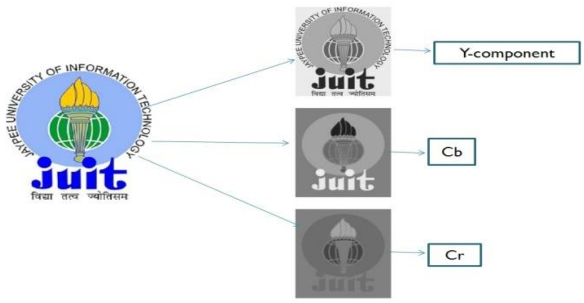

Figure 5: Colored watermark and YCbCr format

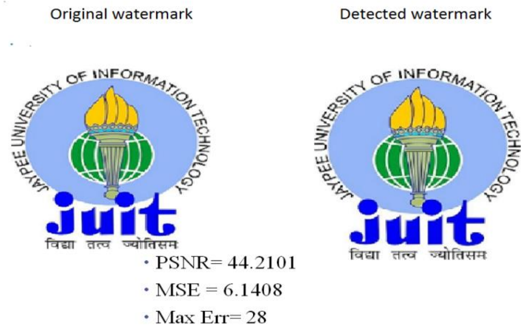

Figure 6: Original and detected watermark

V. CONCLUSION

The proposed approach is more proficient because the quality of extracted watermark is better than [3] in terms of PSNR and BER. Cb of the video frame is taken for embedding the watermark because HVS cannot identify the changes in Cb (Blue chroma) because of its low resolution. Compression attack will not affect the quality of the embedded watermark because we embed the same watermark at every scene changed frame so at the time of extraction we can extract that watermark from the couple of frames and finally collect all extracted watermark and find out the best possible pattern on the basis of image collaboration technique. Secondly it is hard to know the spot where it is inserted, because it is inside the blue chroma (Cb). Another one advantage of this technique is that watermarked video also will not be degraded because the watermark is embedded inside the blue chroma (Cb) that has a very low sensitivity.

Video watermarking is an essential need of copyright protection and a lot of research is still going on to find out the new methods for security and privacy of the multimedia contents. Current methods for video copyright protection techniques are extended form of image watermarking and there is a great scope of innovation. Research can be carried out to establish new strategies for digital video copyright protection.

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