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DWT Based Scheme for Video Watermarking

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Abstract: In this paper a novel video watermarking scheme operating in the discrete wavelet transform is presented. Specifically the input video sequence is partitioned into number of frames for the embedding process. The grayscale image is sliced into bit planes for analyzing the each bit of the image. The sliced bit plane images are permuted and each permuted watermark images are embedded into each frame of the segmented shots with the aid of the watermark embedding. Then the recovery of the watermark is achieved with the help of the watermark extraction. Current scheme allows algorithm design, evaluation, experimentation and robustness.

Keywords: Copyright protection, Discrete wavelet transform, Video watermarking.

I. INTRODUCTION

Video watermarking has been widely used in ownership protection, authentication, and content integrity confirmation of intellectual property in digital form [2]. Watermarking can be described as the process of embedding data into multimedia images, audios and videos [3, 4]. Modern digital watermarking methods concentrate on image and video copyright protection [5]. According to the technique employed to hide the watermark information bits in the host video, watermarking methods can be classified into two major types; they are spatial domain watermarking and transform-domain watermarking. Spatial-domain watermarking methods embed and detect watermark by modifying the spatial pixels values (luminance, chrominance, color space) of the entire video frame [6]. On the other hand spatial pixel values of the host video are modified according to a pre-determined transform by the transform-domain techniques. Transforms such as Discrete Cosine Transform (DCT), and the Discrete Wavelet Transform (DWT), are predominantly used [7].

II. A VIDEO WATERMARKING SCHEME

The new watermarking scheme we propose is based on Discrete Wavelet Transform. Fig. 1 shows an overview of our watermarking process. In our scheme, an input video is split into audio and video stream and undergoes watermarking respectively. On the other hand, a watermark is decomposed into different parts which are embedded in corresponding frames of different scenes in the original video. As applying a fixed image watermark to each frame in the video leads to the problems in maintaining statistical and perceptual invisibility, our scheme employs independent watermarks for successive but different scenes. Applying independent watermarks to each frame also presents a problem: Regions in each video frame with little or no motion remain the same frame after frame. These motionless regions may be statistically compared or averaged to remove independent watermarks, so we use an identical watermark within each motionless scene. With these mechanisms, the proposed method is robust against the attack of frame dropping, averaging, swapping, and statistical analysis. At the same time, error correcting codes are extracted from the watermark and embedded as an audio watermark in the audio channel, which in turn makes it possible to correct and detect the changes from the extracted watermarks. This addition protection mechanism enables the scheme to overcome the corruption of a watermark, thus the robustness of the scheme is increased under certain attacks. This newly proposed scheme consists of four parts, including: watermark preprocess, video preprocess, watermark embedding, and watermark detection. Details are described in the following sections.

A. Watermark Preprocess

Watermark preprocess consists of two parts, video watermark and audio watermark. After both watermarks are preprocessed, they will be embedded into video channel and audio channel, respectively.

Video Watermark A Watermark is scrambled into small parts in preprocesses, and they are embedded into different scenes so that the scheme can resist to a number of attacks specified to the video. A 256-grey-level image is used as a watermark, as shown in Fig. 3a, so 8 bits can represent each pixel. The watermark is first scaled to a particular size with the following equation

$$p + q = n, \quad p \text{ and } q > 0 \tag{1}$$

Where m is the number of scene changes and n, p, q are positive integers. And the size of the watermark should be

$$64.2^p \times 64.2^q \tag{2}$$

Then the watermark is divided into $\mathbf{2^n}$ small images with size 64 × 64. Fig. 2 and 3 show the procedure and the result of watermark preprocess with m = 10, n = 3, p = 1, and q = 2.

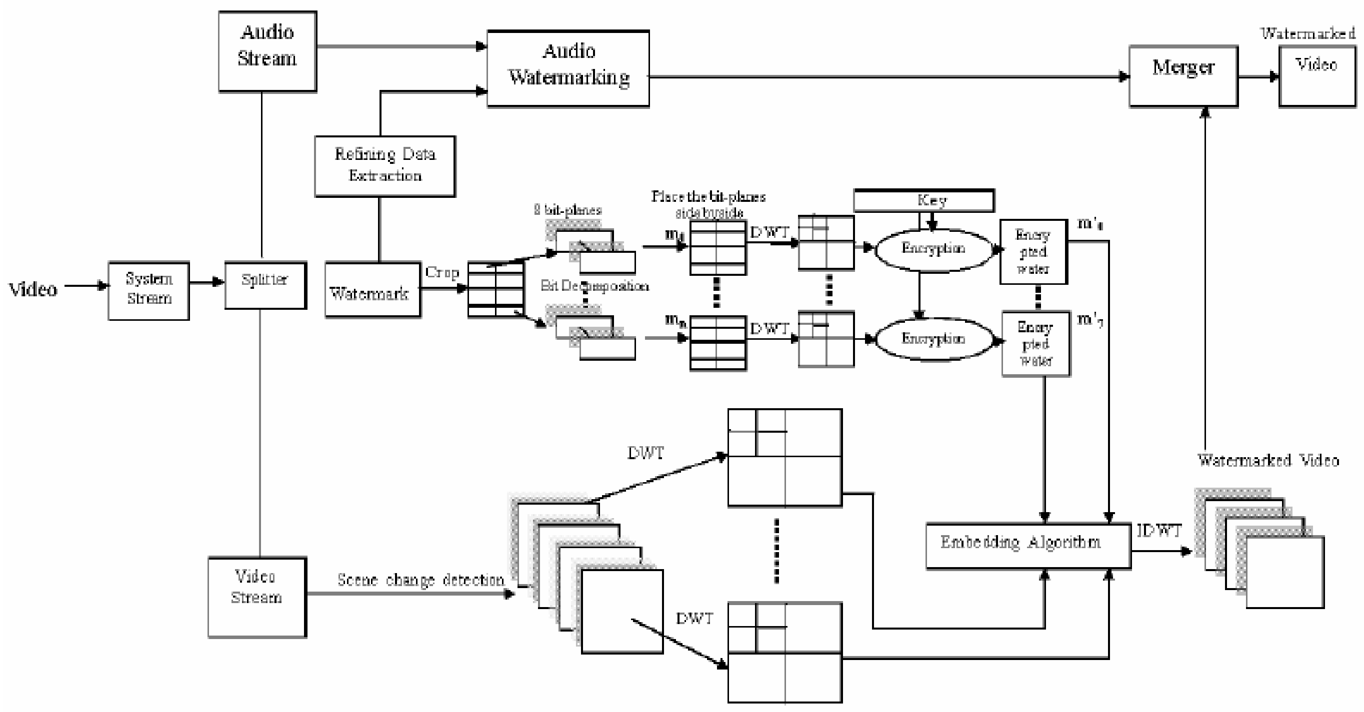

Fig.1. Overview of the watermarking process.

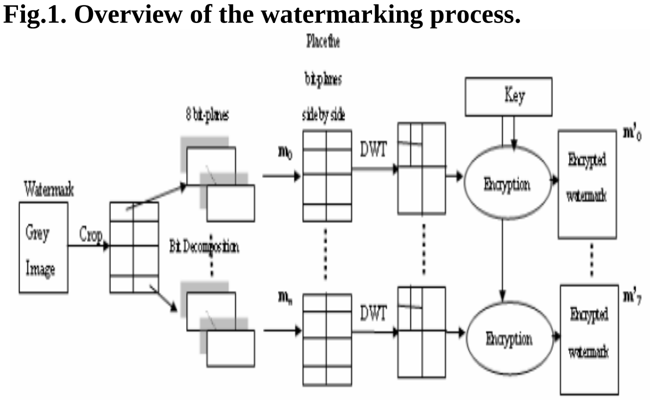

Fig.2. Overview of watermark preprocess.

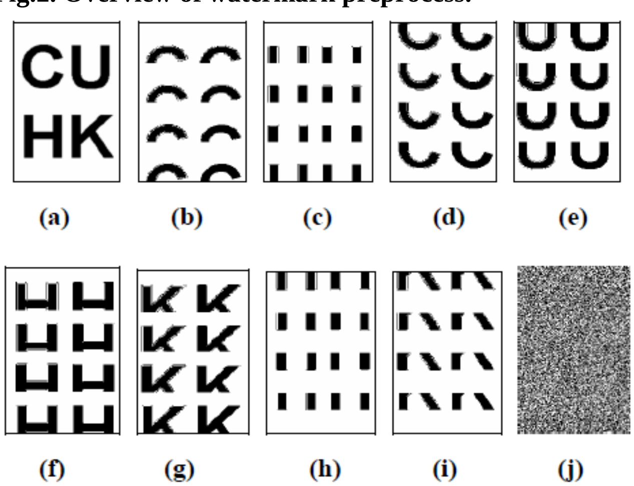

Fig.3.(a)Original watermark (b-i) Preprocessed watermark m_0-m_7 (j) Encrypted watermark m'_0.

In the next step, each small image is decomposed into 8 bit-planes, and a large image m_n can be obtained by placing the bit-planes side by side only consisting of 0's and 1's. These processed images are used as watermarks, and totally 2^n independent watermarks are obtained. To make the scheme more robust, the processed watermarks m are transformed to the wavelet domain and encrypted. Sample preprocessed watermarks are shown in Fig. 3, where (a) is the original watermark, (b)-(i) represent the scrambled watermarks in the spatial domain, and (j) shows the encrypted watermark of (b), i.e., m'_0.

Audio Watermark Error correcting code is extracted from the watermark image and embedded in the audio channel as an audio watermark. This watermark provides the error correcting and detection capability for the video watermark. In detection phase, it would be extracted and used for refining the video watermark. Different error correcting coding techniques can be applied such as Reed-Solomon Coding Techniques and Turbo Coding. Error correcting code plays an important role to a watermark, especially when the watermark is corrupted, i.e., when it is damaged significantly. Error correcting code overcomes the corruption of a watermark, and can make the watermark survive through serious attacks. Moreover, the scheme also takes advantages of watermarking the audio channel, because it provides an independent channel for embedding the error correcting code, which gives extra information for watermark extraction. Therefore, the scheme is more robust than other schemes which only used video channel alone. The key to error correcting is redundancy. Indeed, the simplest error correcting code is simply repeated everything several times.

However, in order to keep the audio watermark inaudible, we cannot embed too much information into an audio channel. In our scheme, we apply averaging to achieve the error code. Within a small region of an image, the pixels are similar. Therefore, an average value of a small region can be used to estimate the pixels within that particular region. The average value of the pixels in each region is calculated as follows:

$$Avg_k = \sum_{i=0}^{x}\sum_{j=0}^{y} W_{j*w+q*x+p*y*w+i} \quad (3)$$

Where k is the k^{th} block of the average image, (p, q) is coordinate of region k, (x, y) is the coordinate of the pixel in region k and x ´ y is the size of a block. A sample is shown in Fig. 4.

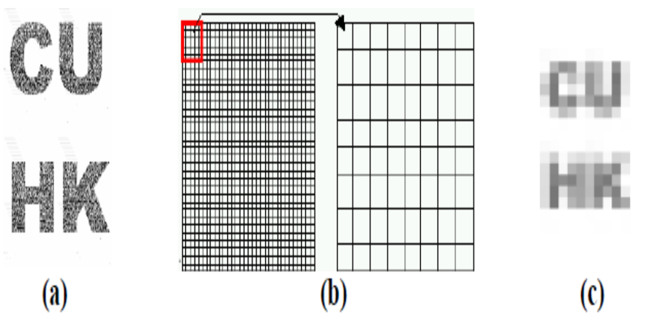

Fig.4. (a) Original video watermark (b) Visualization of averaging (c) Audio watermark (average of a)

B. Video Preprocess

Our watermark scheme is based on 4 levels DWT. All frames in the video are transformed to the wavelet domain. Moreover, scene changes are detected from the video by applying the histogram difference method on the video stream.

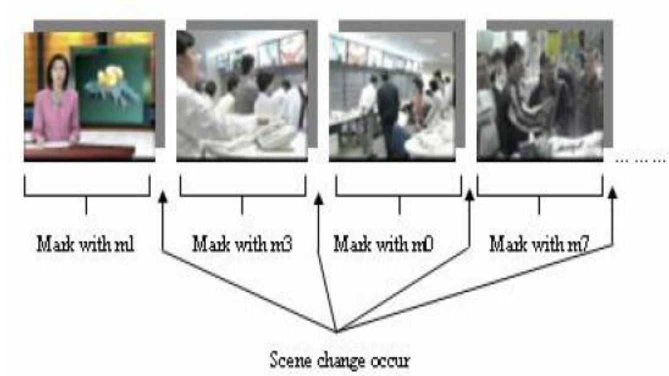

Fig.5. After scene change detection, watermark m1 is used for the first scene. When there is a scene change, another watermark m3 is used for the next scene.

After scene change detection, as shown in Fig.5, independent watermarks are embedded in video frames of different scenes. Within a motionless scene, an identical watermark is used for each frame. The watermark for each scene can be chosen with a pseudo-random permutation such that only a legitimate watermark detector can reassemble the original watermark.

III. DWT BASED PROPOSED WATERMARK SCHEME

The popularity of digital video based application is accompanied by the need of copyright protection to prevent illicit copying and the distribution of digital video. Copyright protection inserts authentication such as ownership information and logo in the digital media without affecting its perceptual quality. In case of any dispute, authentications data is extracted from the media and can be used as authoritative proof of prove the ownership. Watermarking is the process that embeds data called a watermark or digital signature in to the multimedia objects such that watermark can be detected or extracted later to make an assertion about the object. Object may be image or audio or video for the purpose of copyright protection. Digital watermarking techniques must meet the criteria of imperceptibility as well as robustness against all attacks for removal of watermark.

In this paper we proposed an imperceptibility and robust video watermarking algorithm based on Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA). DWT is more computationally efficient than other transform methods like DFT and DCT. Due to its excellent sptio-frequency localization properties, DWT is very suitable to identify areas in the host video frames where watermark can be embedded imperceptibility. It is known that even after decomposition of video frame using the wavelet transformation there exist some amount of correlation between wavelet coefficients. PCA is basically used to hybridize the algorithm as it has inherent property of removing the correlation among the data. i.e. wavelet coefficient and it helps in distributing the watermark bits over the sub bands used for embedding thus result in more robust watermarking scheme that is resistant to almost all attacks .watermark is embedded in to the luminance component of extracted System(HVS).

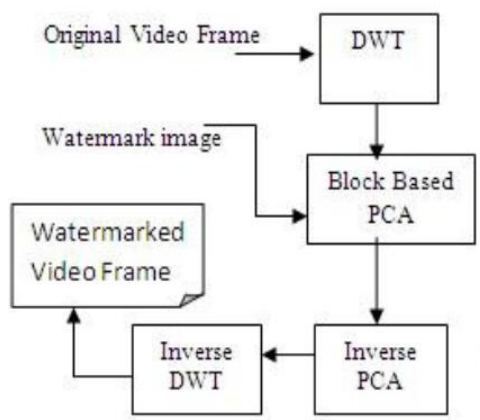

Fig.6. Watermark Embedding Algorithm.

The proposed watermark scheme is based on combining two transform, the DWT and the PCA. Block diagram of embedding and extraction algorithm are as shown in fig.6 and Fig.7. In our method video frames are taken as input and watermark is embedded in each frame by altering the wavelet coefficient of frame by altering the wavelet coefficient of selected DWT sub bands followed by performing the PCA transformation on selected sub bands.

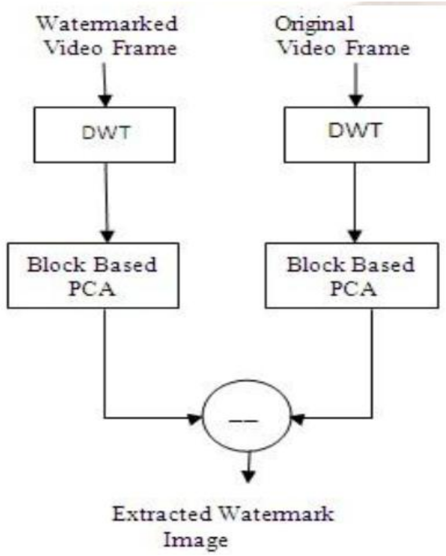

Fig.7. Watermark Extraction algorithm.

A. Discrete Wavelet Transform

The DWT is more popular in signal processing applications. 2D Discrete Wavelet Transform (DWT) decomposes a video frames in to sub images, 3 details and 1 approximation. The approximation sub images is lower resolution approximation image (LL) however the details sub images are horizontal (HL), vertical (LH) and diagonal (HH) detail components. The main advantage of wavelet transform is its compatibility with model aspect of the Human Visual System (HVS) as compared to FFT or DCT. In the proposed algorithm sub bands LL and HH from resolution level 2 of wavelet transform of the frame are chosen for embedding process. The following figure shows the selected DWT bands which used in our proposed algorithm. Embedding the watermark in low frequencies obtained by wavelet decomposition increases the robustness against attacks like filtering, lossy compression, and geometric distortion while making scheme more sensitive to contrast adjustment, gamma correction and histogram equalization. Embedding the watermark in high frequency sub bands makes the watermark more imperceptible while embedding in low frequencies makes it more robust against variety of attacks.

B. Principal Component Analysis

Principal Component Analysis (PCA) is a mathematical procedure that uses the orthogonal transformation to convert a set of observations of possible correlated variables in to set of values of uncorrelated variables called Principal Component. The number of principal component is less than or equal to the number of the original variables. PCA is a method of identifying patterns in data, and expressing the data in such a way that so as to highlight their similarities and differences. PCA is a powerful tool for analyzing data and other main advantages of PCA is that once these patterns in data have been identified; the data can be compressed by reducing the number of dimensions, without much loss of information.

IV.EXPERIMENTAL RESULTS

The experimental results of the proposed digital video watermarking scheme using discrete wavelet transform are presented. The watermarked video sequences possess superior Peak Signal to Noise Ratio (PSNR) and visual quality for grayscale watermark images. The output acquired from the proposed video watermarking scheme has been evaluated by PSNR and NC (Normalized Correlation).The current scheme is evaluated by two video samples such as Football, Claire. Fig.8 shows the original input Football video sequence, watermark image, watermarked video sequence and the extracted watermark image.

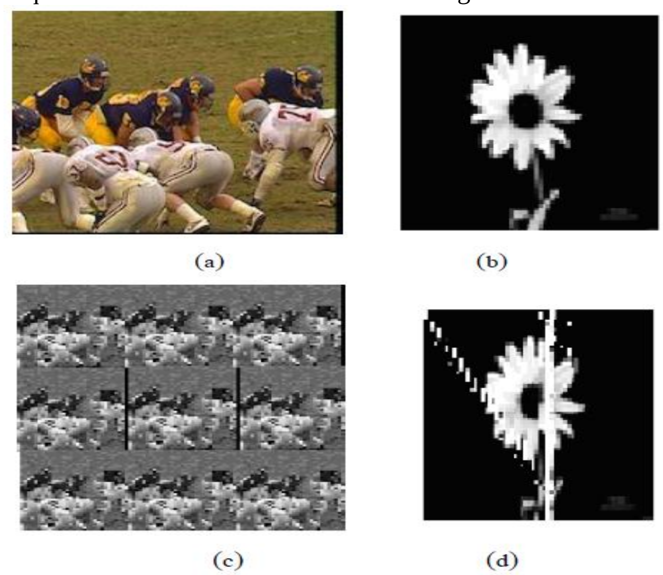

Fig.8. (a) Input Football video sequence, (b) Watermark image, (c) Frame Football Watermarked video, (d) Extracted watermark image

Similarly, the fig.9 shows the results of the Claire video sequence.

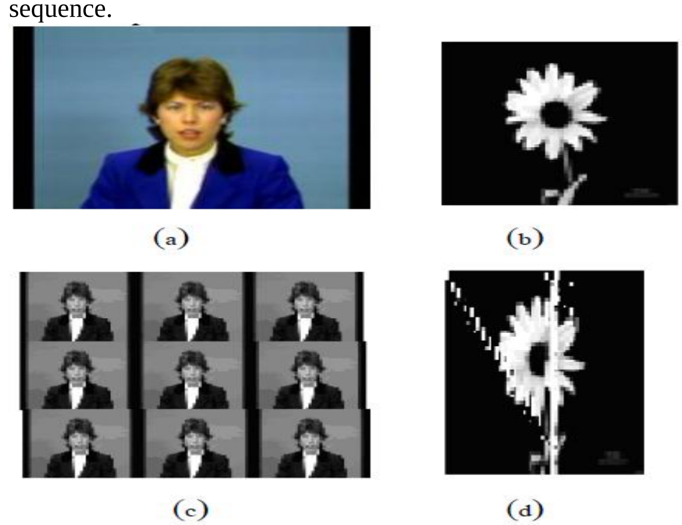

Fig.9.(a) Input Claire video sequence, (b)Watermark image,(c) Frame Claire Watermarked video,(d) Extracted watermark image.

Fig.10 depicts the PSNR graph of the Football and Claire video samples respectively. The NC plot of the Football and the Claire video sample is shown in figure

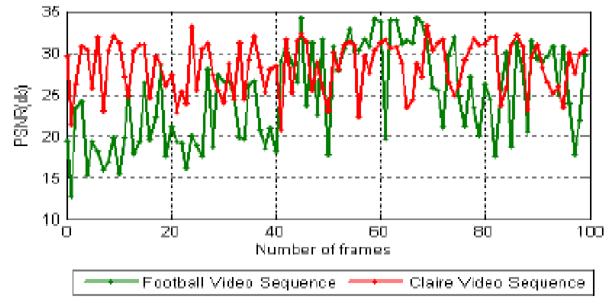

Fig.10. PSNR graph of the Football, Claire video sequence

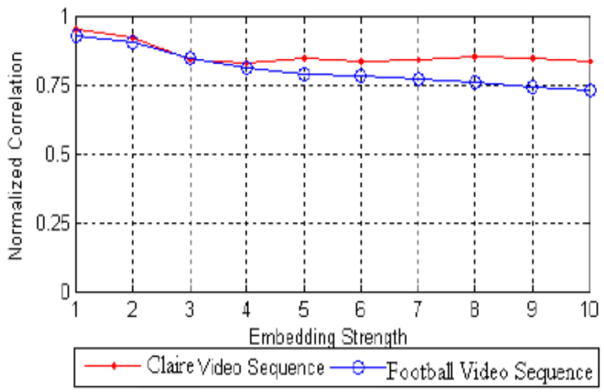

Fig.11. NC plot for Football, Claire video sequence

A. Evaluation Results

To prove the effectiveness of the proposed scheme the results are compared with the existing method [9]. Table 1 shows the PSNR values with different frame number for the Football video sequence. Table 2 shows the PSNR values with different frame number for the Claire video sequence.

TABLE 1: PSNR values with different Frame number (PSNR in db)

Video sequence	Frames	Embedding Strength=1 PSNR(db)	Embedding Strength=5 PSNR(db)	Embedding Strength=10 PSNR (db)
Football	20	28.53	24.16	23.26
	40	30.51	24.67	24
	60	34.09	37.192	36.37
	80	26.24	27.12	26.132
	100	29.66	27.63	26.65

TABLE 2: PSNR values with different Frame number (PSNR in db)

Video sequence	Frames	Embedding Strength=1 PSNR(db)	Embedding Strength=5 PSNR(db)	Embedding Strength=10 PSNR (db)	
Claire		20	28.68	27.31	23.99
		40	28.05	25.37	24.45
		60	30.26	27.67	26.80
		80	30.97	26.15	25.08
		100	30.27	26.98	26.11

Table 3 shows the performance evaluation in terms of PSNR for Football and Claire video sequence. The results of the comparative data clearly demonstrate the efficacy of the present methodology as evidenced from the PSNR value.

TABLE 3: Performance evaluation of PSNR in db

Video sequence	Proposed PSNR(db)	Existing(8) PSNR(db)
Football	37.192	33.21
Claire	34.81	31.20

B. MPEG compression

MPEG compression is one of the basic attacks to video watermark. The video watermarking scheme should robust against it. Table 4 shows the robustness evaluation in terms of NC for Football and Claire video scene after MPEG2 compression.

TABLE 4: Robustness evaluation of NC

Video sequence	Proposed NC	Existing(8) NC
Football	0.7286	0. 6783
Claire	0.7082	0. 6459

V. CONCLUSION

This paper proposes a novel scheme for video watermarking. In the present investigation an efficient video watermarking scheme using DWT to protect the copyright of digital video sequence is demonstrated. This is attaining by watermark embedding and watermark extraction process. Experimental results proved that the proposed scheme is efficient by means of imperceptibility and robustness.

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