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3D anaglyph image watermarking approach

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Abstract

In this paper, a binary watermark is embedded and extracted using principal component analysis along with non-subsampled contourlet transform. Before the use of aforementioned techniques, the binary watermark is scrambled, for which we have used Arnold transform. This will by default add a level of security measures without a password. The approach as presented in the following paper is very efficient, novel, robust and blind. We have also considered the possibility of image processing attacks, hence we have employed non subsampled contourlet transform for the same. The scheme is tested on various images and we have come to a conclusion that this scheme is very performance oriented when compared to the existing watermarking techniques using 3D anaglyphic images.

Keywords—PCA (Principal Component Analysis), DCT (Discrete Cosine Transform), NSCT (Non Subsampled Contourlet Transform) , DFB (Directional Filter Banks)

I. Introduction

In the current digital age, where internet and technologies have grown to a very large extent providing a lot of services to every individual, we can easily see increasing misuse and ill-usage of such technologies. To give some examples about the same, we can always look up to multimedia content such as image, videos, audio etc. The main victim of such losses are the ones who have created the information. This is where copyright protection comes into picture. It now becomes more important to make intact the copyright of its original owner. This is where we drive motivation for providing a watermarking technique for 3D anaglyph images.

In simple words, watermarking is a process of adding some message (which is to be transmitted) into another message (which acts as a cover for original message) so that it hides. There are multiple applications for this technique. Complete embedding and extraction procedures that involves adding a message into a cover and then taking it out again is termed as a complete watermarking approach. We also need to take care about an important aspect of watermarking, which is it should not degrade the cover in any case, at least not visible to naked eyes.

In the given paper, we have tried to present a novel and blind watermarking scheme for 3D anaglyph image. The scheme is robust and can be used for protecting the copyrights. In the proposed methodology, we will input a 3D anaglyph image. Sub band will be extracted from this image by the use of N-level non subsampled countourlet transform. Then we apply PCA which helps us to search the significant coefficients in the sub bands selected. Finally we embed the watermark into these coefficients. At the receiver's side, blind watermark extraction, as stated before, is applied so as to get back the binary watermark image hidden inside the cover data. We have tested the suggested algorithm for various attacks as well. Some of the commonly used attacks were cropping, histogram equalization, gaussian noise etc.

The paper is organized as follows. In the next section, we have discussed about preliminary information about the important and relevant concepts. The next section i.e. section number 3 discusses about the proposed methods about watermarking scheme. Section 4 deals with comparison with the existing systems. And in the end, we have conclusions in section 5.

II. preliminaries

A. Nonsubsampled Countourlet Transform

Nonsubsampled countourlet transform, commonly known as NSCT is characterized by the following integral properties: flexible, multiscale, multidirectional, efficient transform and shift invariant. The main items it consists of is a filter bank that helps to make subbands out of a 2D frequency plane. The mechanism behind construction of these subbands is as follows: it first takes out the nonsubsampled directional filter bank and nonsubsampled pyramid structure, it then combines them both so as to get the best frequency hence achieving better subband decomposition. Atrous filtering system is used to implement it, which is shown in equation 1 below.

$$y[n] = \sum_{k \in sup\ p(h)} h[k]x[n-Sk] \quad (1)$$

As mentioned earlier, the shift invariant nature of filtering is a property of multiscale of the nonsubsampled countourlet transform which helps in achieving a decomposition of the sub band. The results are pretty redundant because at each stage of the process, 1 band pass image is generated. In accordance to the process the filters are up-sampled, we get a shift invariant and highly directional expansion along with a nonsubsampled directional filter bank. The output in return will eliminate both down-samplers and up-samplers in the directional filter bank. This also turns off both the down-samplers and up-samplers in each of the 2 channel filter bank in the directional filter bank structure in tree form.

B. Principal Component Analysis

The following information describes the vital steps to be taken for implementation of principal component analysis. Each of the image pixel value is subtracted from the mean value of all pixels, in order to centralize the pixel values. This will help us to calculate the covariance matrix. Then we calculate the eigenvectors and eigenvalues of the covariance matrix obtained from previous step. In order to find the principal component of this data, we pull out the eigenvector with the highest eigenvalue. We then transpose eigenvectors and multiply this on the left of the transposed original data.

C. Arnold Transform

The sole purpose of Arnold transform is to add a level of security to the operation. It is an image scrambling methods. The 2 main characteristics of Arnold transform are periodicity and simplicity. Therefore, if we have the periodicity information we can easily restore the source original image. This will be done by a number of iterations. Keeping the image security property in mind, this is used in various applications.

III. proposed watermarking scheme

Following is an explanation of the proposed watermarking scheme. As discussed in the above sections, we are employing Arnold transform to add the security feature to the operation. It provides a non-password security. It is applied on the watermark image which is in binary form. As with the most watermarking schemes, this scheme is also divided in 2 main parts: embedding the watermark in cover image and extracting the watermark in watermark embedded cover. We start by employing a pair of stereo images obtained from Middlebury stereo images dataset. These 2 separate stereo images are joined together to make 1 complete 3D anaglyph image by the process of linear projection. This 3D anaglyph image will be considered as the cover image for embedding operation. We then move forward with transforming this cover image by making use of N-level non subsampled countourlet transform. This transform will give us multiple sub bands. We are going to select the sub band with the minimum variance, and use it for the embedding process.

A. Embedding

Following steps needed to be followed for the embedding procedure. A detailed flow diagram is provided in figure 1.

- 3D anaglyph image is obtained. We use the left and right stereo images and combine them by the use of linear projection method as discussed earlier.
- Apply N-level non subsampled countourlet transform to the cover image obtained in above step.
- Select the sub band with minimum variance.
- Apply PCA to the selected sub band.
- Scramble the binary watermark image (whose size is 32 X 32) using Arnold transform. Apply *p* number of transitions.
- Scrambled binary watermark image is embedded into the selected sub band obtained after PCA transform
- Apply inverse PCA to the sub band which is modified in previous step.
- N-level inverse non subsampled countourlet transform is applied to sub bands, which produces the watermarked cover image (3D anaglyph)

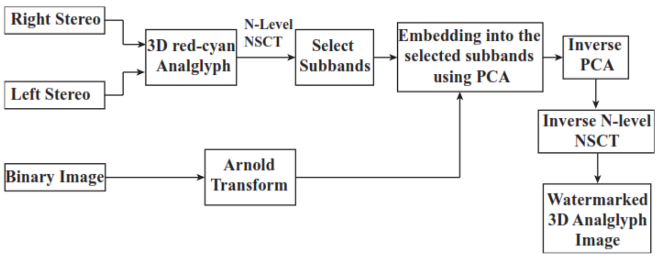

Fig. 1. Proposed embedding procedure.

B. Extracting

Following steps needed to be followed for the extraction procedure. A detailed flow diagram is provided in figure 2. Please note the while extraction process, no information is used from source data. This is a blind and robust watermarking scheme. We make use of the 3D watermark cover image obtained after embedding. We do make use of the level N of non-subsampled countourlet transform and the p iterations of Arnold transform. They are used as the secret keys.

- Apply N-level non subsampled countourlet transform to the 3D anaglyph cover image.
- Select the sub band with minimum variance
- Apply PCA to this sub band
- Watermark pixels are extracted from this output
- Inverse 2D Arnold transform is applied p number of times, assembling the watermark embedded.

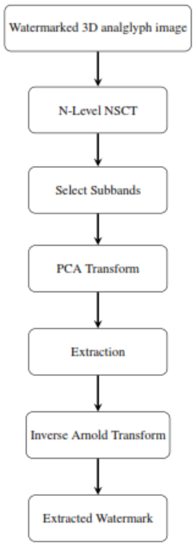

Fig. 2. Proposed extraction procedure.

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IV. results and discussion

In calculating the results for the analysis, we have used various original 3D anaglyph images in the process. These images are used to evaluate the performance of the system. The original 3D anaglyph images are of the size 370 x 460 x 3. We have then applied liner projection on the pair of 3D anaglyph images and then, the output is resized to 256 x 256 x 3, which is to be used as the final cover image. A binary image watermark is used whose dimension is 32 x 32. For the N level non subsampled countourlet transform, the level of transform that we have used is 4. Hence the particular sub band that is selected is calculated at level 4 of the non subsample countourlet transform.

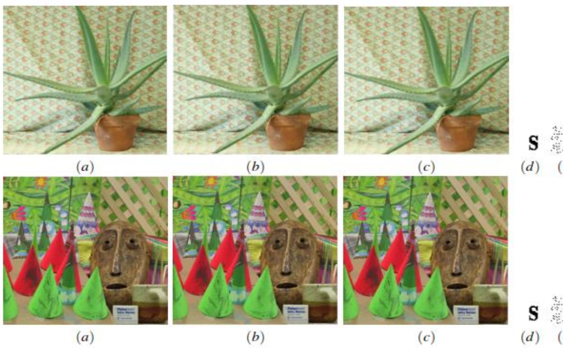

Fig. 3. (a) Left stereo image (b) Right stereo image (c) Generation of 3D anaglyph image (d) Original watermark image (e) Scrambled watermark after arnold transform (f) Reconstructed watermark

A. Imperceptibility

If we are to check the PSNR value of the original watermark and the reconstructed watermark, then the value so obtained must be more than 51db. This is a sign of an imperceptible watermarking system. In the proposed system, we have managed to get a PSNR value of 69db. Hence it can be very easily said that out proposed system is highly imperceptible.

B. Robustness

In terms of how a watermarking system holds against the intentional attacks from an outside hacker or a non authorized entity determines the robustness of that watermarking scheme. We were able to work on the robustness of this system by comparing the original watermark with the watermark obtained after the image processing attack. We have measured the robustness with the help of normalized correlation and have managed to get an NC value of 0.9 for most of the attacks.

C. Security

Arnold transform adds a level of seurity to our system. We have to transform/scramble the original watermark image using p iterations of arnold transform. Then at the receiver side, we have to again apply arnold transform p iterations to reconstruct the original watermark again from the scrambled version of it. This is how we obtain the original watermark image back from its unscrambled version.

TABLE I. COMPARISON OF PSNR VALUES OF WATERMARKED 3D ANAGLYPH IMAGES

Images	Doll	Cones	Tsukuba	teddy	Venus	Baby1
PSNR value(dB)	69.2284	69.1916	69.031	69.1916	69.0913	69.2943

TABLE II. NORMALIZED CORRELATION VALUES AFTER THE ATTACKS

Attacks	Aloe	Baby	Flowerpot	Lamp shade	Midd1	Doll	Rocks	Wood	Plastic	Monopoly
Averaging Filtering([7×7])	1	1	1	1	1	1	1	1	1	1
Median Filtering([7×7])	1	1	1	1	1	1	1	1	1	1
Sharpening(50%)	1	1	1	1	1	1	1	1	1	1
Color Quantization	0.99924	0.99812	0.99953	0.99832	0.99815	0.9983	0.9996	0.99993	0.99841	0.99872
Gaussian Noise	1	1	1	1	1	1	1	1	1	1
JPEG Compression	1	1	1	1	1	1	1	1	1	1
Rotation(50deg)	0.9995	0.9995	0.9995	0.9995	0.9995	0.9995	0.9995	0.9995	0.9995	0.9995
Cropping(50%)	1	0.9981	0.9982	0.9995	0.9989	0.99983	0.9998	1	0.9985	0.9981
Scaling	0.99804	0.99881	0.99834	0.99991	0.99898	0.99954	0.99859	0.99818	0.99978	0.99962
Contrast Adjustment	1	1	1	1	1	1	1	1	1	1
Translation	1	1	1	1	1	1	1	1	1	1
Resizing	1	1	1	1	1	1	1	1	1	1
Impulse Noise	0.99867	0.99954	0.99807	0.99813	0.99923	0.99829	0.99856	0.99934	0.99904	0.99933
Histogram Equalization	1	1	1	1	1	1	1	1	1	1
No Attack	1	1	1	1	1	1	1	1	1	1

TABLE III. COMPARISON WITH OTHER WATERMARKING SCHEMES

	Proposed method			Bhatnagar			Liu and Tan			IVY		
Images	Cones	Tsukuba	Dolls	Cones	Tsukuba	Dolls	Cones	Tsukuba	Dolls	Cones	Tsukuba	Dolls
No Attack	1	1	1	1	1	1	1	1	1	1	1	1
Averaging filter([7×7])	1	1	1	0.8503	0.8543	0.8422	0.7560	0.7502	0.7547	0.9514	0.9401	0.9517
Median Filtering([7×7])	1	1	1	0.9406	0.9357	0.9372	0.8091	0.8171	0.8003	0.9937	0.9898	0.9910
Gaussian Noise	1	1	1	0.8491	0.8514	0.8435	0.8169	0.8118	0.8157	0.9499	0.9583	0.9420
JPEG Compression	1	1	1	0.9719	0.9763	0.9757	0.9440	0/9497	0.9475	1	1	0.9999
Cropping	0.99978	0.99978	0.99974	0.9649	0.9856	0.9558	0.6472	0.6420	0.6441	0.9754	0.9799	0.9629
Resizing	1	1	1	0.9475	0.9455	0.9424	0.7511	0.7678	0.7517	0.9876	0.9689	0.9559
Rotation(50degree)	0.9995	0.9995	0.9995	0.8909	0.8970	0.8891	0.6838	0.6887	0.6853	0.9812	0.9989	0.9887
HE	1	1	1	0.9597	0.9548	0.9593	0.9593	0.9672	0.9508	0.9912	0.9919	0.9809
Contrast Adjustment	1	1	1	0.9768	0.9777	0.9744	0.9517	0.9599	0.9537	0.9760	0.9800	0.9718
Sharpening	1	1	1	0.9956	0.9963	0.9964	0.9906	0.9876	0.9931	0.9999	0.9989	0.9979

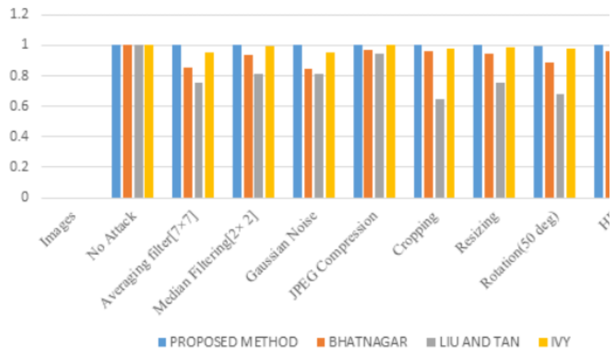

Fig. 3. Comparison of proposed watermarking scheme with other schemes

V. conclusion and future work

In this paper, we have implemented a watermarking scheme for 3D anaglyph cover image. For keys, we have used the level of non-subsampled contourlet transform and the number of iterations of the arnold transform. This is suffice to say that in order to obtain the original watermark embedded in the cover image, an individual needs these 2 keys. This will help in copywriting the information. As a future work, we can look for incremental PCA.

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المستخلص :

العلامة المائية الثنائية يتم تضمينها واستخراجها باستخدام تقنيات التحليل للمكونات الرئيسية جنبا الى جنب مع استخدام تحويل الشكل الخارجي للعينات الغير فرعية ، قبل استخدام التقنيات المذكورة أعلاه العلامه المائية الثنائية شوشت لذلك نحن استخدمنا تحويل ارنولد. وهذا بشكل افتراضي يضيف مستوى من الاجراءات الامنية بدون كلمة مرور .منهاح البحث كما هو موضح في الورقة التالية هي فعالة جدا و جديدةو قوية . وتم اخذ في نظر الاعتبار الامكانية الهجمات باستخدام معالجة الصور وبالتالي قمنا بتوظيف تحويل الشكل الخارجي للعينات الفرعية لنفسها . المخطط تم اختباره على صور متنوعه وحصلنا على استنتاجات ان أداء هذا المخطط موجه جداَ عندما نقارن بتقنيات العلامه المائية الحالية او السابقة باستخدام النقش ثلاثي الابعاد على الصور .