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# DIGITAL VIDEO WATERMARKING USING SVD IN THE DCT DOMAIN

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**Abstract:** *Digital water marking is one of the important concepts used for digital documentation protection. Several researchers proposed various algorithms and methods on digital documentation and protection. Each type of algorithms has its own advantages and limitations. No method can provide fully perfect solution. Each type of solution has robustness to some type of attacks but is less resilient to some other types of attacks. Focus of the current paper in this field is to make the watermarking algorithms resilient to noises. In case of practical application, choice of solution type depends on the nature of application and requirements. We have implemented here block based SVD algorithm and DCT SVD based algorithm, both these algorithms are tested for various types of attacks. Quality factors PSNR and correlation are evaluated for SVD and hybrid DCT-SVD for comparative analysis. It is found that correlation for noises like Gaussian , Poisson , Laplacian, and attacks like Gaussian blur, pixelate, JPEG are more resistant in the first band of hybrid DCT-SVD compared to SVD. These results demonstrate that DCT-SVD based algorithm is relatively more robust against Noises which are considered very significant attacks against any watermarking scheme. Hence this watermarking scheme can be considered as noise invariant.*

**Key Words:** Video Water Marking, SVD algorithm, DCT SVT, Quality factors PSNR, JPEG,

## Introduction:

Digital watermarking is the process of embedding information into a digital signal which may be used to verify its authenticity or the identity of its owners, in the same manner as paper bearing a watermark for visible identification. In digital watermarking, the signal may be audio, pictures, or video. If the signal is copied, then the information also is carried in the copy. A signal may carry several different watermarks at the same time. M. L. Miller et.al. explained the watermarking techniques can be classified according to the application domain, according to the type of document, according to the human perception and according to the application. Watermarks can be embedded into the multimedia content in spatial domain or in frequency domain.

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Spatial: These are constructed in the image spatial domain and embedded directly into an image's pixel data.
Frequency domain: watermarking methods may use several different domains, such as discrete cosine transformation (DCT) domain, discrete Fourier transformation (DFT) domain, discrete wavelet transformation (DWT) domain, fast Hadamard transform (FHT) domain etc. The watermarking algorithms can be named according to the embedded multimedia content, such as text, image, and audio and video watermarking. Human perception is also used as a criterion to classify the watermarking techniques. Visible Logos are the examples of the visible watermarks that indicate the owner of the content Invisible watermarks alter the media in a way that they are perceptually unnoticeable. They can only be detected by using an appropriate detection method. They identify the owner of the digital media. The two types of invisible watermarks are robust and fragile watermarks. Purpose of the robust algorithms is the endurance of watermark after possible distortions such as possible compressions, filtering, and noise additions. C. Shoemaker et.al explained about the various manipulations, they have explained the Fragile watermarks are used to detect if there is any manipulation or modification on the digital content. These modifications would change or destroy the watermark. Figure. 1 indicates the classification of various watermarking techniques.

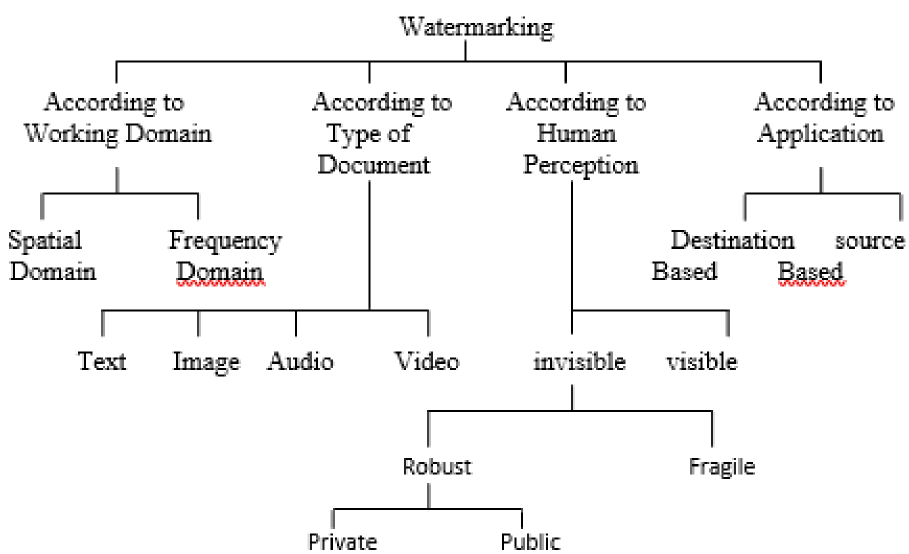


Figure1.Classification of watermarking techniques.

The paper is organized as follows: Section 2 gives a general description of a Singular Value Decomposition. Section 3. Gives the transformation techniques in water marking techniques. Section 4 explains the experimental results and discussions followed by conclusion in section 5.

## 2. Singular Value Decomposition (SVD)

SVD is an effective numerical analysis tool used to analyze matrices. In SVD transformation, a matrix can be decomposed into three matrices that are of the same size as the original matrix. From the view point of linear algebra, an image is an array of non-negative scalar entries that can be regarded as a matrix. Without loss of generality, if *A* is a square image, denoted as

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$A \in Rn \times n$ , where $R$ represents the real number domain, then SVD of $A$ is defined as $A=USVT$.

Where $U \in Rn \times n$ and $V \in Rn \times n$ are orthogonal matrices, and $S \in Rn \times n$ is a diagonal matrix, as

$$S = \begin{bmatrix} \sigma_1 & & & \\ & \sigma_2 & & \\ & & \ddots & \\ & & & \sigma_n \end{bmatrix}$$

Here diagonal elements i.e. σ's are singular values and satisfy

$\sigma 1 \geq \sigma 2 \geq \ldots \sigma r \geq \sigma r+1 \geq = \ldots\ldots = \sigma n=0$. SVD is an optimal matrix decomposition technique in a least square sense that it packs the maximum signal energy into as few coefficients as possible. It has the ability to adapt to the variations in local statistics of an image.

**Properties of SVD**

Generally, a real matrix $A$ has many SVs, some of which are very small, and the number of SVs which are non-zero equals the rank of matrix $A$. SVD has many good mathematical characteristics. Using SVD in digital image processing has some advantages :

- The size of the matrices from SVD transformation is not fixed and can be a square or a rectangle.
- The SVs (Singular Values) of an image have very good stability, i.e. when a small perturbation is added to an image, its SVs do not vary rapidly
- SVs represent algebraic image properties which are intrinsic and not visual.

### 3. The Transformation Techniques:

**The DCT transform:** The discrete cosine transforms is a technique for converting a signal into elementary frequency components. It represents an image as a sum of sinusoids of varying magnitudes and frequencies. With an input image, x, the DCT coefficients for the transformed output image, y, are computed. Where x, is the input image having N x M pixels (m, n) is the intensity of the pixel in row m and column n of the image, and y (u, v) is the DCT coefficient in row u and column v of the DCT matrix. The discrete cosine transform (DCT) is closely related to the discrete Fourier transform by R. liu et.al and Liu et.al. It is a separable linear transformation; that is, the two-dimensional transform is equivalent to a one-dimensional DCT performed along a single dimension followed by a one-dimensional DCT in the other dimension. These results in giving three frequency sub-bands: low frequency sub-band, mid-frequency sub-band and high frequency sub-band. Figure.2 Computation of 2-D DCT using seperability property

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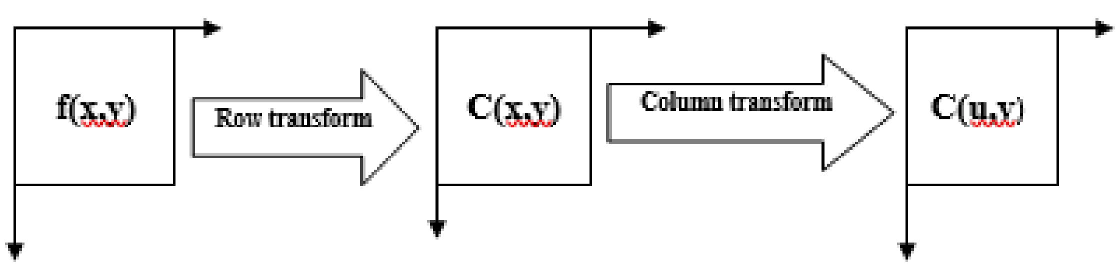


Figure2: Computation of 2-D DCT using seperability property

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**DCT-SVD based algorithms**

A hybrid method based on DCT and SVD has been proposed by Sverdlov et al. [4]. First, applying the DCT to the whole cover image DCT coefficients are mapped to the four quadrants using the zig zag sequence and then SVD is applied to each quadrant. These four quadrants actually represent frequency bands from the lowest to the highest. Singular values of the DCT-transformed visual watermark are then used to modify the singular values of each quadrant of the cover image. In this paper, the cover image has been divided into four blocks and as a result the size of the visual watermark is one quarter of the size of the cover image. It has been shown that embedding data in lowest frequencies is resilient to one set of attacks while embedding data in highest frequencies is resilient to another set of attacks. Robustness of this algorithm has been tested against a set of attacks including Gaussian blur, Gaussian noise, JPEG compression, rescaling, cropping, histogram equalization, gamma correction etc. Robustness against rotation operation is not very satisfactory which has been reflected by the value of correlation coefficient. This algorithm is not resistant to translation operation.

Two-dimensional DCT transformation is applied to the whole image but frequency coefficients need to be mapped from the lowest to the highest in a zigzag order to 4 quadrants, in order to apply SVD to each block. Figure.3 gives the Zigzag order for the image.

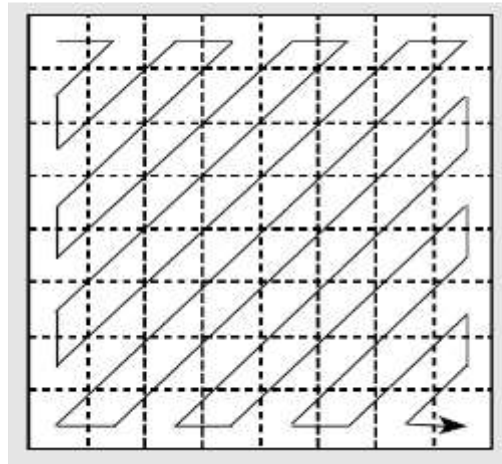

Figure3: Zigzag order

All the quadrants will have the same number of DCT coefficients. For example, if the cover image is 256x256, the number of DCT coefficients in each block will be 16,384. I label these blocks B1, B2, B3, and B4. Y. H. Wang et.al, G. and E. Ganic et.al discussed the DCT coefficients with the highest magnitudes are found in quadrant B1, and those with the lowest magnitudes are found in quadrant B4. Correspondingly, the singular values with the highest values are in quadrant B1, and the singular values with the lowest values are in quadrant B4. The largest singular values in quadrants B2, B3, and B4 have the same order of magnitude. So, instead of assigning a different scaling factor for each quadrant, I have used only two values: One value for B1, and a smaller value for the other three quadrants. Figure.4 indicates the Mapping of DCT coefficients to four blocks.

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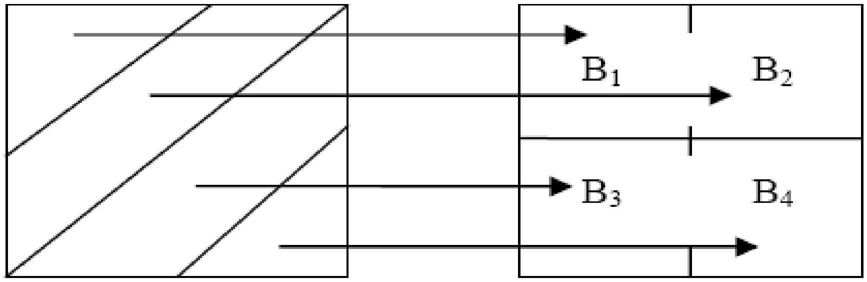

Figure 4: Mapping of DCT coefficients to four blocks

## Steps of the algorithm

Unlike most watermarking schemes, this algorithm also consists of three steps: Embedding watermark, Preprocessing before extraction and Extraction of watermarks.

## Embedding of watermark:

1. Apply DCT to the whole video frame A and map the DCT coefficients into 4 quadrants: B1, B2, B3, and B4 using the zigzag sequence.

2. Apply SVD to each quadrant: AK = UkAΣkAVkAT, k = 1,2,3,4 where k denotes B1, B2, B3, and B4 quadrants.

3. Apply DCT to the whole visual watermark W and then apply SVD to the DCT- transformed visual watermark W: W = UWΣWVWT.

4. Modify the singular values in each quadrant Bk, k = 1,2,3,4, with the singular values of the DCT-transformed visual watermark: λi*k =λik + αk λwi , i = 1,…,n, where λik , i=1,…,n are the singular values of ΣkA , and λwi, i = 1,…,n are the singular values of ΣW

5. Find the 4 sets of modified DCT coefficients: A*k = UkAΣ*kAVkAT, k = 1,2,3,4.

6. Map the modified DCT coefficients back to their original positions.

7. Apply the inverse DCT to produce the watermarked video frame.

8. Repeat the above process for each required frame.

## 4.Experimental Results and Analysis

This sections is for describing the conducted experiment and evaluating the results with comparison to an existing watermarking scheme. This watermarking scheme is noise invariant due to its robustness against Gaussian noise, laplasian noise, Poisson noise, etc. Moreover, it is resilient to many other attacks including Gaussian Blur, JPEG compression, histogram equalization etc. The video frames used in this experiment is 'foreman.yuv' of size 144 × 176and the watermark image is 'cameraman.tif' of size 72 ×88. This algorithm has been implemented using MATLAB (7.10.0). Now- a- days most of the watermarking schemes are implemented using MATLAB. Figure.5 indicates the original video frame and watermarking image.

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| | |
|---|---|
|  |  |
| (a) Original video frame | (b)original watermark image |

Figure 5. Original video frame and watermark image

According to the algorithm the video frame is divided into four blocks and the watermark image is embedded in each block. In the extraction phase, all four watermark images from each block are extracted. Quality of the extracted watermark is evaluated visually and using the Pearson correlation coefficient between the original watermark image and extracted watermark image from each block. Pearson correlation coefficient is calculated using the original vector of singular values and extracted vector of singular values for each quadrant. The Pearson product moment correlation coefficient is a dimensionless The Pearson correlation coefficient is a

## Without attacks:-

dimensionless index that ranges from -1.0 to 1.0, and reflects the extent of a linear relationship between two data sets which are two images in this case.

## Best Extractions

This watermarking scheme has been tested against several attacks including rotation, rescale, Gaussian noise, histogram equalization etc. Figure6. Gives the watermarked video frame and Extracted watermark image for the analysis. Figure7. PSNR for different attacked frames & correlation coefficients.

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| | |
|---|---|
|  |  |
| Watermarked video frame | Extracted watermark image |

Figure 6. Watermarked video frame and Extracted watermark image

## With attacks:-

| ATTACK | PSNR | Extracted image | correlation coefficient. |
|---|---|---|---|
|  Salt & peppar | 17.1328 |  | 1.0000 0.5933<br>0.6002 0.6100 |
|  Poisson | 22.5016 |  | 1.0000 0.6586<br>0.5988 0.6727 |
|  Histogram equalisation | 15.7675 |  | 1.0000 0.7884<br>0.8376 0.9578 |

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| | | | |
|---|---|---|---|
|  Sharp | 17.9013 |  | 1.0000 0.7003<br>0.7439 0.8901 |
|  Speckle | 16.9347 |  | 1.0000 0.6045<br>0.5966 0.6163 |
|  Gaussian | 18.9962 |  | 1.0000 0.5972<br>0.6029 0.6204 |
|  Rotate | 5.6719 |  | 1.0000 0.8027<br>0.8170 0.7897 |

Figure 7. PSNR for different attacked frames & correlation coefficients

## CONCLUSION

There are several types of algorithms for watermarking. Each type of algorithms has its own advantages and limitations. No method can provide fully perfect solution. Each type of solution has robustness to some type of attacks but is less resilient to some other types of attacks. Main focus of the current paper in this field is to make the watermarking algorithms resilient to noises. In case of practical application, choice of solution type actually depends on the nature of application and requirements. We have implemented here block based SVD algorithm and DCT SVD based algorithm, both these algorithms are tested for various types of attacks. Quality factors PSNR and correlation are evaluated for SVD and hybrid DCT-SVD for comparative analysis. It is found that correlation for noises like Gaussian , Poisson , laplacian and attacks like Gaussian blur, pixelate, JPEG are more resistant in the first band of hybrid DCT-SVD compared to SVD. These results demonstrate that DCT-SVD based algorithm is relatively more robust against Noises which are considered very significant attacks against any watermarking scheme.

Hence this watermarking scheme can be considered as noise invariant.

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